THE

ENGINEERING MAGAZINE

VOL. III. JULY, 1892. NO. 4.

SOME LESSONS IN RAPID TRANSIT.

By Louis Heilprin.

THE problem of rapid transit in great centers of population is one of such universal interest, and it is now pressing for solution in so many cities, that engineers and business men the world over can not go amiss in posting themselves thoroughly upon the phases of the subject now presented for practical solution in New York. Each city has its own problem, and there are of course certain conditions present at one point which do not exist elsewhere. But it is everywhere a question of railways, high speed and large seating capacity; and hence the attainment of these ends in any one locality is very apt to offer a solution of the problem which will be, in the main, of universal application. And in New York—the metropolis of the Western world, built upon a long, narrow island—the conditions are so unusual and the requirements so extreme, that what accomplishes the purpose there will undoubtedly serve as an object lesson of the greatest possible utility and value elsewhere.

The opinion is entertained at present by the Rapid Transit Commission of New York that the needed additional means of travel will have been supplied by the construction of a system of railroads, mainly underground, consisting of two four-track arteries, one on the east side and one on the west side of the city, extending from the vicinity of Union Square to Harlem, with a double-track continuation in the suburban sections, and of a main four-track artery extending from Union Square to the Battery. A close examination will show that this presumption is not well founded and not likely to be justified by events.

Copyright, 1892, by The Engineering Magazine Company.

Experience has taught us that in the case of great engineering enterprises in a rapidly-growing population, the most generous provisions for the demands of the future are apt to prove inadequate. The construction of the present system of elevated railroads once appeared to be the solution of the problem of rapid transit in New York. Fifteen years ago most people in that city no doubt felt confident that two double-track routes would suffice. Four such roads were built. Within two years the system had proved itself to be a failure with respect to meeting the demands of the public. Increasing the frequency of train-service, lengthening the trains, introducing more powerful engines—nothing has availed to check the increasing discomfort of travel or the diminution in its rapidity. Many persons, indeed, are beginning to lose sight of the fact that the roads were constructed for the purposes of rapid transit. For a portion of the day the average rate of speed on Third avenue has been reduced to about ten miles an hour, although between many of the stations a speed of twenty-five to thirty miles an hour is maintained for a few seconds at a time. Ten miles an hour can hardly be called rapid transit in this age of air-brakes, when on a perfectly straight and well-constructed roadbed almost any degree of speed is deemed compatible with safety.

But what the elevated roads have failed to provide is not rapid locomotion so much as means of traveling like human beings. On the two principal lines the travel during the busiest portion of the day is about double what can be carried comfortably. The seating capacity of a train of five cars, as now run, is about 250, while the full complement reaches or exceeds 500. On these two lines alone eight tracks would be required to handle the present traffic so as to afford sitting-room to every passenger. It may here be asked what do we mean by the present traffic? Promise seats to all passengers, and the amount of traffic will be swelled by the many thousands who now prefer the accommodations of the surface roads to the crowded trains of the elevated roads. At a low estimate the traffic of the latter would be increased by 25 per cent., and we should find that ten tracks on Sixth and Third avenues would barely suffice for the exigencies of the present.

Let figures speak. We shall measure transporting capacity by the number of seats that can be furnished per hour. With trains running on a single-track road at intervals of one minute, each train to consist of five cars of fifty seats each, that number is 15,000. With ten tracks, therefore, we should be able to provide

only 75,000 through seats per hour in one direction. During the four busiest hours of the day we should be able to transport in one direction no more than 300,000 passengers.

This rate of transportation would about represent the demand that would now be made upon the Sixth- and Third-avenue lines alone in the thickest of the evening crush, were the ordinary comforts of travel secured to the public. Under present conditions, with a dozen lines of horse-cars actively competing, it is safe to assert that on the four elevated roads taken together the rate at which the tickets are dropped into the boxes at all the stations exceeds at the busiest time of the day 100,000 per hour. Four elevated tracks each on Third and Sixth avenues would fail to meet the present demands of the traveling public. A well-constructed and well-equipped viaduct road along the line of either of these thoroughfares, affording real rapid transit between the Battery and the northern limits of the city, could not conveniently dispose of the traffic it would be called upon to handle without running trains in one direction on three tracks at least. Ordinarily speaking this would mean twelve tracks for the two lines, but in order to meet possible objections we shall allow that while six tracks are being used in one direction four tracks will suffice for return trains.

At this point it may be argued that we might add to the carrying capacity of the roads by running the trains at a higher rate of speed than at present, thereby diminishing the average duration of the trips. But increasing the speed cannot of itself add to the carrying capacity of a railroad, otherwise than by enabling a given amount of rolling-stock to do more service in a given time. A higher rate of speed does not by any means imply increased carrying capacity. This will be determined solely by the interval of time between successive trains. If the schedule provides, for example, for the despatching of thirty trains per hour on one line of rails, then it will be immaterial as far as carrying capacity is concerned whether the average speed is ten or forty miles an hour. In the former case, indeed, four times as many cars may be required as in the latter, but if the supply of cars does not run short, there will be no diminution in the carrying capacity. The same number of trains will pass any particular station within a given time in the one case as in the other, and the chance of obtaining a seat will be the same. Increasing the speed will not diminish the pressure on the roads. On the contrary, it can be shown that it will tend to increase it, and this paradox enters as a cardinal factor

in the problem of rapid transit. Suppose that with a maximum velocity of twenty miles an hour it is safe to allow trains to follow each other at intervals of one minute; this will give us, under existing conditions, 15,000 seats per hour. Now suppose it were proposed to increase the maximum speed to forty miles a hour. Evidently it will no longer be safe to run the trains with a leeway of only one minute. At twenty miles an hour a train can be brought to a standstill in about six seconds, while at forty miles an hour twelve seconds or more will be required, the retarding action of the brakes not increasing with the velocity. In these twelve seconds the faster train will have passed over four times the ground traversed by the slower train in six seconds. Thus, if the latter can be brought to a standstill in a distance of ninety feet, the former will (roughly speaking) run 360 feet from the moment the brakes are applied until its motion is completely arrested. A still more important factor in the determination of the minimum interval between trains is the violence of the shock in case of a collision. With a maximum of twenty miles an hour a serious collision would be almost an impossibility. With forty miles an hour there is always the possibility of a great catastrophe.

The minimum interval at twenty miles an hour would have to be more than doubled for forty miles an hour. It could hardly be safe to allow trains to succeed each other at the latter speed at a shorter interval than two-and-a-half minutes. This would give us twenty-four trains, or 120 cars, per hour, with a seating capacity for through passengers of only 6000. In the case of rapid-transit roads in a city of 1,700,000 inhabitants, whose dwellings and places of business occupy a narrow strip fifteen miles long, and whose capacity for locomotion far exceeds the real carrying capacity of the existing lines of communication, an increase of velocity in the transporting apparatus implies an increased number of tracks.

If it be proposed to run fast express trains between the Battery and Spuyten Duyvil on one side and between the Battery and Fordham on the other, and to provide equally rapid transit for all points above Eighty-sixth street, then our ten tracks on the two principal railroads alone would soon have to be expanded to twelve or fourteen. Were a high rate of speed attempted for all classes of travel, short hauls as well as long hauls, even if the length of the trains were increased to seven cars of the type now employed, then ten tracks, all used in the same direction, could not be relied upon to convey more than about 125,000 through passengers per hour with comfort

and absolute safety. On two of the elevated roads—on Second avenue and Ninth avenue—the intervals between the trains could be reduced considerably below what they are now, but the former at least, even with much more frequent trains, could not do more than conveniently accommodate the tide of travel that passes over it in the morning and evening hours. To sum up, a satisfactory system of rapid transit for New York as it is to-day would require in place of the existing ten tracks (including two underground tracks on Park avenue) a total of eighteen to twenty tracks.

Thus far we have been considering the needs of New York as the city exists to-day. Let us now attempt to look a short distance into the future. Within ten years, at the present rate of increase, about half a million people will have been added to the population of New York. With such improved means of communication as would be afforded by the proposed eight underground tracks, a vast impetus would be given to building operations in the upper part of Manhattan Island and the annexed district. It would be as though a whole new city had been created. We cannot be far from the truth if we assume that an accession to the population of half a million souls will represent an addition to the daily number of rapid-transit passengers of about 200,000, or 100,000 in each direction. This figure would represent an additional pressure upon the railroads during the busiest part of the day of 20,000 passengers an hour in one direction. As the capacity of a transit system of the high-speed pattern can hardly be rated above 10,000 per hour per track, this additional pressure would have to be met by three if not four additional tracks. If during the next ten years there should be a considerable shifting of population from the district south of Twenty-third street to the upper portions of the city, a fresh wave of travel would impose an additional pressure as great as a double set of rails would bear, and if the old crowded tenement quarters should begin to drain northward, still another pair would be required from this cause alone.

In addition to all this, traffic in general tends constantly to swell, irrespective of increase in population; witness the constantly increasing mass of non-residents who patronize every means of conveyance in and around the city. Making allowance for this natural increase, it is a fair estimate to make when we say that to provide satisfactorily for the needs of New York in the immediate future, a system of railroad transit really expeditious, convenient and safe, operated either by steam or electricity, or both, ought to embrace not less than twenty-five sets of rails. This is 50 per

cent. more than would be afforded by the existing elevated roads and the eight tracks of the proposed underground systems, namely, sixteen in all. By the time the projected underground railroads can be completed, New York will not be much nearer to the solution of the problem of rapid transit than at the time of the inauguration of overhead transportation. There was a time when there was a charm in the term "double-track"—a time when most people believed that the carrying capacity of a four-track steam-road was practically boundless. There was a time when the idea of eight parallel elevated tracks, without crossings or obstructions, implied to every one the end of the discomforts and annoyances of travel. There are those now who believe that eight additional tracks will solve the problem. To believe this is to be lacking in perspective and to ignore the experience of the past.

No system of rapid transit ought to be deemed sufficient to meet the needs of the immediate future of New York (which by 1900 will have nearly doubled the population that it had in 1878, when the Sixth-avenue elevated road was opened) that does not offer a transporting capacity, combining speed with comfort, of about 150,000 passengers in one direction per hour. The proposed eight underground tracks will not permit this figure to be reached unless the idea of really rapid locomotion is abandoned and the system of haulage, with respect to speed and stops, is assimilated to that now existing on the elevated roads. But what New Yorkers are looking forward to is real rapid transit and not pseudo-rapid transit. If the means of locomotion are to be mainly underground then is actual rapidity of transit more imperative than ever. There is no reason why we should be satisfied with the ten miles an hour which the Third-avenue elevated road affords below Sixty-seventh street, and the eleven or twelve miles which the easier grades enable the Sixth-avenue line to achieve below Fiftieth street, even if each passenger were sure to find a luxurious seat on entering the car.

We have been discussing the projected underground scheme on the assumption that it would offer eight additional tracks, thus doubling the existing capacity for rapid-transit communication. But as a matter of fact the scheme provides for only four tracks in that part of the city south of Union Square. This idea of compressing the traffic into a four-track main artery under Broadway for a distance of two miles and a half (Fourteenth street to South Ferry) is simply preposterous. Even if the scheme provided for an efficient system of loops in the vicinity of Union Square, so that a

considerable proportion of the trains might be cut off at that point so as to relieve the lower section, the feature in question would be a great mistake. But if the stream of traffic conveyed over a system of eight tracks is to be made to converge into four, then we are simply crippling the means of transportation represented by that system. If all the trains are to be run over the entire course we shall simply be establishing a limit of carrying capacity which will be determined by the work which two lines of track used in one direction can be made to perform. Assuming that the terminal loops and switches can be made to operate so efficiently that not a moment is lost in reversing the direction of the trains, how many seats shall we be able to carry from the City Hall to Union Square in an hour? Whatever figure we shall arrive at will measure the maximum carrying capacity of the entire system.

If we despatch trains at the rate of one a minute on each of two tracks, if each train consists of seven cars, and if each car has a seating capacity of fifty, we shall obtain a total maximum of only 42,000 seats per hour. This would not be the solution of the problem of rapid transit for New York. But is the despatching of trains of the size in question at the rate of one a minute on a single track really compatible with rapid transit? Considering the inevitable proximity of the stations to each other in the lower part of the city, and the fact that the trains in their northward course by the time they reach Fourteenth street will have taken on board about three-fourths of their total complement of through passengers, there can be no exaggeration in assuming that in this section of two miles and a half the average rate of speed, including stops, during the hours of greatest traffic, would not exceed ten miles an hour. Fifteen minutes would have to be consumed between Fourteenth street and South Ferry. There could hardly be any pretense of running trains in this portion of the route on "express" schedule, for this would imply an inadmissible lengthening of the intervals between the trains.

If eight underground tracks are needed above Fourteenth street it is absurd to imagine that four will suffice for the remainder of the distance. But the idea of having only four tracks for these two-and-a-half miles evidently has its root in the notion that the great underground thoroughfare ought to be as far as possible directly under Broadway. It is true that more than four parallel tracks cannot very well be located on the same level under Broadway without descending to a greater depth than the Commission

considers admissible. But is there any absolute necessity for locating the underground road precisely on the line of this thoroughfare? Better travel in comfort under the Bowery or South Fifth avenue than be packed like herrings under the aesthetic blocks of Broadway buildings. It might be well, indeed, for the east and west lines to converge somewhere in the vicinity of Union Square so as to meet in a capacious transfer station, which should permit passengers from the east side passing over to the west side and *vice versa;* but after thus meeting, the two roads ought to diverge again and pursue an independent course to the extremity of the island, from a quarter to an eighth of a mile on either side of Broadway.

Another exhibition of short-sightedness is the opinion that a double track on either side will suffice for the demands of New York beyond the Harlem river. These outlying portions of the metropolis to be brought close to the business portions must be served with a system of transit embodying a very high rate of speed. We have seen that the capacity of a double-track road with trains run at express speed can hardly be rated higher than about 6000 passengers per hour in one direction. Now if the region along the Harlem and about Spuyten Duyvil creek had the transit facilities which it asks for, by the time the district was built up a double-track road would in all probability not accommodate one-third of the travel, the condition being that speed and comfort alike shall be secured to passengers.

Whether or not the construction of underground railroads as the chief means of conveyance in the metropolis be rendered imperative by present and future conditions—there are those who believe that the idea of a grand system of overhead communication ought not yet to be abandoned. One thing certain is that in spite of all possible improvements in the matter of lighting and ventilation, the necessity of underground travel will be in itself nothing short of a misfortune to the citizens of New York. If it is to be endured, let such provision at least be made that the traveling public shall not have to face underground the discomforts, delays and vexations which beset our present aerial transportation.

The New York of the immediate future will be a city of two million inhabitants, this mass of humanity oscillating like a pendulum back and forth once a day. To provide for this movement in a satisfactory way, to reduce the friction within endurable bounds, the system of communication will have to be on a scale far more gigantic than our engineers seem prepared to contemplate.

CONVICT LABOR IN ROAD-MAKING.

By Albert Roberts.

IN a paper printed in the September (1891) issue of this Magazine, on the "Iniquity of Leasing Convict Labor," the suggestion was ventured by the present writer that the best practicable solution of the convict-labor problem was perhaps to be found in the employment by the State of the prison labor in road-building. Further reflection and closer investigation tends to an increase of faith in the efficacy of the proposed solution, and the apparent unanimity with which the suggestion has been approved by the contemporary press has strengthened that faith almost to the conviction that in no better way may the State employ its convicts so economically and less in conflict with the wage interests of its free industrial population; with greater benefit to agricultural, mineral and timber development; with larger revenue returns and with better moral and physical results to the convicts.

The problem of convict employment is one of the most serious that confronts the State governments of the southern portion of our Union, and no other section of the country more urgently needs an improved road system. The question of the improvement of the public highways was never more than now a subject of vital and general public interest. It is coming in for consideration by leading newspaper reflexes of public sentiment, and the pens of economists of recognized preëminence are enlisted in the elucidation of the best methods of road-building, while capable engineers have discussed instructively in these pages the comparative merits of Telford, Macadam and other scientific road systems. The economic advantages of good roads are so manifold and so obvious that an enumeration of them would seem a work of supererrogation. One pointed illustration, however, may profitably be pursued, even to the point of "damnable iteration," to secure its forcible impression, and that is as to the enormous and continual waste and loss from inferior roads.

The Board of Trade in a Tennessee town, in a recent memorial to the Legislature, demonstrated that bad roads were costing the people of that commonwealth more than seven million dollars annually. Professor W. W. Carson, of the University of Tennessee,

after careful investigation found the average cost of hauling to the Knoxville market by wagon to be $7.50 per ton—aggregating one-and-a-quarter millions a year on the total tonnage hauled. He maintained that this hauling could have been done for half the sum over good dirt roads and for one-sixth of it over good Macadam roads, saving a million dollars annually. Professor Richard T. Ely, of the Johns Hopkins University and Secretary of the American Economic Association, affirmed that poor roads cost this country over twenty dollars a horse, and Professor Jenks, of Knox College, Illinois, thinks fifteen dollars a horse a low estimate for this loss. Mr. Hord, a former Commissioner of Agriculture for the State of Tennessee, estimated the number of horses, mules and asses in that State, in 1889, at 476,000. The number has increased since his estimate, but taking this number and the lowest estimated loss per horse, say fifteen dollars, and an aggregate loss of $7,140,000 a year for one State is shown. From tables calculated by Professor Carson for an agricultural experiment-station, it was shown that on gravel a horse will draw nearly one-and-a-half times the load, and on Macadam, over three times the load, he can draw on a dirt road. Of course there is great economy of drawing power in the proper grading of roads, and disregard of this fact has wasted large quantities of money in the road-building of the past. The greater speed attained on scientifically-graded and patent race-tracks illustrate the advantages of grade.

Another economic phase of hard-road building especially interesting to landed proprietors—whether land-poor owners of timber, mineral or farming land—is that of the material appreciation of land values as the resultant of the introduction of good roadways. Railways through an undeveloped region do not more surely and speedily enhance the value of the lands thereby brought into closer proximity to market. The rule which regulates the development of suburban real estate by making it more accessible through smooth carriage-drives and rapid-transit facilities applies to real estate of remoter country districts. This has been proved in States where farms along turnpikes or Telford and Macadam roads have enhanced in value 100 per cent. A farm will sell for more money when it fronts a hard road leading to the nearest market than one situated along a country lane or a dirt road, even if nearer to the market. A shrewd Jerseyman seems to have profited by a realizing sense of the wisdom of this maxim. In a recent communication to a Rochester newspaper he recites that his brother owned a farm

of one-hundred-and-twenty-three acres in Union county, New Jersey. A few years ago he valued the land at from $50 to $75 an acre but was unable to sell it even at that price. The farm was unprofitable because bad roads made it expensive to get its produce to market, and the profits did not represent a fair rate of interest on the estimated value of the land. In course of time the road improvement "craze" struck Union county and about sixty miles of good Telford highways were put down, and the result to this New Jersey farmer was that he has since refused $200 an acre for his land.

The cry that increased taxation more than eats up the increased valuation does not hold good where the increase of valuation is $125 per acre. Neither does the question of comparative cost in excess of revenue from traffic apply in the case of suburban electric railways which are actually run in some quarters at a loss, by land-improvement companies, which find their compensatory return in the enhanced value of adjacent suburban territory. It has been demonstrated that every dollar put into a good roadway in front of a tract of land is more than doubled in the selling price of the land and it is only lack of capital that checks the more general application of the principle. An illustration of the profits of road-building by private enterprise is furnished by the New Jersey writer above referred to, who recites his experience in the purchase, a few years ago, of forty-five acres of land for $1500 an acre, not far from Orange, New Jersey. Encouraged by his brother's good fortune in Union county, he opened up this land and put in the best kind of twelve-inch Telford road. This, with other improvements, brought the expense of the land to him up to $10 a front foot—but he sold it off nearly as fast as he could draw up the deeds, and none of it for less than $30 a front foot. There were seventeen acres on the other side of the road that had been offered to him for $1200 an acre, which he had neglected to buy. The road built by his own enterprise increased the value of his neighbor's seventeen acres and he was glad, in the course of a year, to buy it at $2000 an acre, and this last purchase he improved with cross Telford roads and, in a few months thereafter, sold enough to pay the purchase price and cost of improvements, while he claims that he could get for the ground he has left, $100,000. He affirms that every dollar he made out of that land came from the improvement of the roads. This may be an exceptional case, and it is not to be denied that advantageous environment, pros-

perous seasons, and growing confidence in the future of a region are factors of appreciation, the beneficial effects of which are accelerated by the addition of good roads, but the fact remains that good roads increase land values largely and rapidly.

As the enhancement of values is accompanied by corresponding increase of assessment for taxation, the inference is inevitable that good roads must enlarge the revenues of the State and hence, the feasibility of public road construction by the State government. The success which has attended this system of internal improvements by the State of New Jersey has evidenced the practicability of State road-construction and the beneficial results of the movement in that State may have influenced to some extent the movement in New York, in which State it is proposed to now employ the convict labor in road-construction. Such an utilization of convict labor is coming to be generally regarded—especially in the Southern States, where objections have been raised to the leasing of convict laborers to private parties—as furnishing a timely and felicitous solution to the perplexing problem of prison management, rendering those penal institutions as nearly self-sustaining as possible while removing, as far as practicable, the evils of friction between free and convict labor. The plan proposed in the latter State provides that all male prisoners over eighteen years of age and physically able shall be enrolled by the prison warden as subjects to draft for manual labor on the public roads—the State Engineer to decide what roads shall be improved, the general work to be under his supervision, and prisoners furnished on his requisition with proper guards. The New York plan further provides for removable board shanties every eight miles on the road to be improved, each to accommodate twenty convicts, who shall work the road four miles on each side of their camp and not more than three-fourths of the eligible prisoners to be worked on the roads at any one time. The tools necessary to carry on the work are to be manufactured in the main prison building and on this latter work might be employed those prisoners serving long sentences for major crimes. Another excellent provision of the New York plan is that eight hours are to constitute a day's work and every convict who faithfully performs his duty is to have 10 per cent. of his sentence commuted, over and above all commutations already made by law.

Practical experiment doubtless will reveal wherein this or similar laws for the employment of convicts on road-building may be amended advantageously, and the most economic methods of so

utilizing convict labor will be evolved from the practical application of the system. That such out-of-door employment of the prisoner will be most conducive to his health—therefore more humane than working him in badly-ventilated mines and prison shops—does not require argument. It cannot be doubted, either, that the moral effect upon the convict will be better. The economy of the system, to the State, is obvious. Costly prison factory-buildings with expensive machinery equipment will not be required. There would be less loss of labor through sickness. On the other hand, the increased revenues from increased assessment of taxable lands enhanced in value by road-improvement should fully compensate for whatever increased expenditure might be required for guarding the prisoners. In the Southern States, rich in the volume and variety of their natural resources of wealth, the long summers are favorable to out-door employment of convicts. It is not surprising, therefore, that the proposition to employ convicts in building roads should meet with such public favor, in a section of the country whose transportation facilities are comparatively limited. The betterment of the wagon-road system would be followed by a more rapid railway development, and although the president of an important trunk-line of railway declared in a recent address before the Brotherhood of Locomotive Engineers at Atlanta that "too many roads are built where they are not needed," there would be greater demand for new rail-lines and more tonnage for them to haul, if tributary wagon-roads were better and more numerous. The suggestion by Colonel Albert A. Pope, in a well-considered paper on the public highways, in the March number of *The Forum*, of a trunk system of interstate roads, is worthy of consideration. This writer recommends that the State either own or control and maintain some through highways connecting principal towns in the State and connecting these with principal towns of neighboring States where they are most needed. These would be followed naturally by an arterial system of tributary cross-roads or feeders.

The interstate trunk-road system that has been suggested is no new idea. Before the era of railroad building in the Ohio-river valley there was a hard road from Louisville, Kentucky, to Nashville, Tennessee, considerably over a hundred miles in length and scarcely less noted in its day than the famous road from London to Dover, over which traveled the Royal Mail. This Kentucky and Tennessee road was the main highway from South to North—its only competitor, as an avenue of travel, being the Cumberland

and Ohio rivers. It connected with a superb system of hard roads in middle Tennessee, converging upon the capital of that State like the spokes of a wheel. These roads were built more than half a century ago, under a State policy of internal improvements inaugurated under Whig administration. To encourage the building of these roads the Legislature authorized an issuance of State bonds bearing 6 per cent. interest, and these bonds were given to the turnpike companies as a bonus in proportions of $5000 per mile of road. The companies paid to contractors $10,000 per mile for building eighteen-foot roadways—the payments being $5000 in road bonds and $5000 in road stock, per mile. Shrewd contractors soon discovered that they could, with cheap, regular and reliable slave labor, build a mile of road for considerably less than $5000 in bonds, and that the $5000 in stock was almost net profit, and, in consequence, there was eager competition for contracts. The policy of pledging the State's credit for this purpose was severely condemned by local economists at the time and since, and the tax-burden it involved was a factor in the movement which a few years ago culminated in the sealing of the State debt, but these roads have proved a legacy to this generation of incalculable benefit, greatly enhancing land values and making the region of country thus blessed the envy and the admiration of other communities throughout the South.

Traditional prejudice against internal improvements is gradually giving way to the argument of necessity in the practical solution of the prison-labor problem. The States now deriving profit out of leases of convict labor to private parties may be reluctant to forego that advantage, but public sentiment decrees that the leasing system must go, and public opinion is fast crystalizing upon the moral precept that no commonwealth should make of its penal institutions a matter of profit any more than it should expect to make money out of its asylums for the blind, dumb and insane.

In the experiment of working leased convict labor, sufficient time has not elapsed for the accumulation of statistics upon which may be based comparative estimates of the economic advantage of convict labor over free labor. The interests and views of lessor and lessee are so divergent and conflicting that it is difficult to strike an average, but in the matter of reliability and regularity and freedom from interruption by labor strikes, the advantage of convict labor (as of slave labor thirty years ago) over free labor, is obvious. That convict labor is profitable, as well as reliable, is

evidenced by the competition for it among contractors. The possible loss to the contractor from disability by disease or from the escape of prisoners has to be taken into the account. An old prison warden estimates this at about 33⅓ per cent. of the prison roster, and he declares that he could get more work out of one able-bodied Irish ditcher or spader, at $1.50 per day, than out of two convicts.

Estimates of the cost of maintenance of convict laborers vary from 30 cents to 50 cents per day for each man. One of the chief items of cost is in the pay of guards. Experience shows that one guard is required to every eight men. Probably a smaller number of guards would be required where the men are selected—taking what are known as the "trusties" and short-term convicts. Taking this class for out-of-door service, and by allowing commutation of term of imprisonment for good behavior, and making attempts to escape involve the penalty of longer imprisonment and less congenial labor for the balance of the term, it is believed, would render the prisoners less difficult to guard and admit of a reduction of the guard force, which would lessen the cost. The labor can be obtained at less expense where employed within the prison enclosure because of the fewer guards required than when worked outside the prison, in mines, or on farms or roads. A prison warden of large experience estimates the cost of maintenance, per man, at 40 cents per day within the prison walls and 50 cents per day where worked outside with increase of guards.

The Tennessee Penitentiary at present has about 1500 prisoners, of whom some 350 (including seventy-five female convicts) are employed in the main prison-building. The rest are employed generally in the coal mines of east Tennessee, and some on a farm near the main prison and others in sewer building in the city of Nashville. The entire labor of the prison is leased by the Tennessee Coal and Iron Company, the lessees paying the State $100,500 per annum, or an average of $69 per convict. The only expense to the State is in the payment of the salaries of the superintendent and warden of the Penitentiary, who are State officers. The lessees pay all the expense of maintenance—food, clothing, medical attendance, guarding and transportation from the prison to the mines. To employ this labor in the construction of public roads would practically cost the State the $100,500 now derived from the lease, added to the salaries of superintendent and warden, and the maintenance of the prisoners. The compensatory features would

be: a felicitous solution of the problem of prison maintenance least in conflict with free labor; a better system of public roads with a saving of millions in wear and tear of teams; in quicker transportation to market, enhanced realty values and correspondingly increased State revenue from assessments. The distribution pro rata of the labor by counties or townships is a matter for future legislative consideration. The best plan for guarding and sheltering the men while at work on the roads must be evolved out of practical experiment. So far the plan suggested in the bills before the New York Legislature seems most feasible, providing for removable board shanties every eight miles on the roads to be improved, each shanty to cost not exceeding $250 and to accommodate twenty convicts.

But these are matters of detail for future intelligent legislation based upon actual experience. The consensus of opinion among the advocates of a betterment of the public wagon-roads seems to favor State control as the only practical method for securing a perfect road system. So various are the road laws in the different States that it is irrelevant to offer suggestions as to desirable road laws which shall apply to all localities, but the road laws of the State should be elastic enough to cover all conditions and satisfactorily meet all requirements.

In the building of such roads and in the maintenance of the same, the labor of the prisons could be constantly employed. The construction of a perfect road system would require many years, but the sooner the great work is inaugurated the sooner will the benefits be realized. The public wagon-roads of England and the Continent are the growth of a century, but they are enduring monuments to the civilization and enlightenment of the age which produced them.

The newly-aroused interest of the farmers in governmental affairs, as evinced by recent organized action, would indicate that representatives of the farmer class mean to make their influence felt in the legislation of the future, to the end that agricultural industries may be favored. In no better way could this influence be exerted than in the betterment of the common highways over which the farmer brings the products of his soil and toil to market. It would be a more practicable method of aiding agriculture than visionary schemes of financial aid through sub-treasury devices. Besides an improvement of the road system has the merit of general advantages to all other industries.

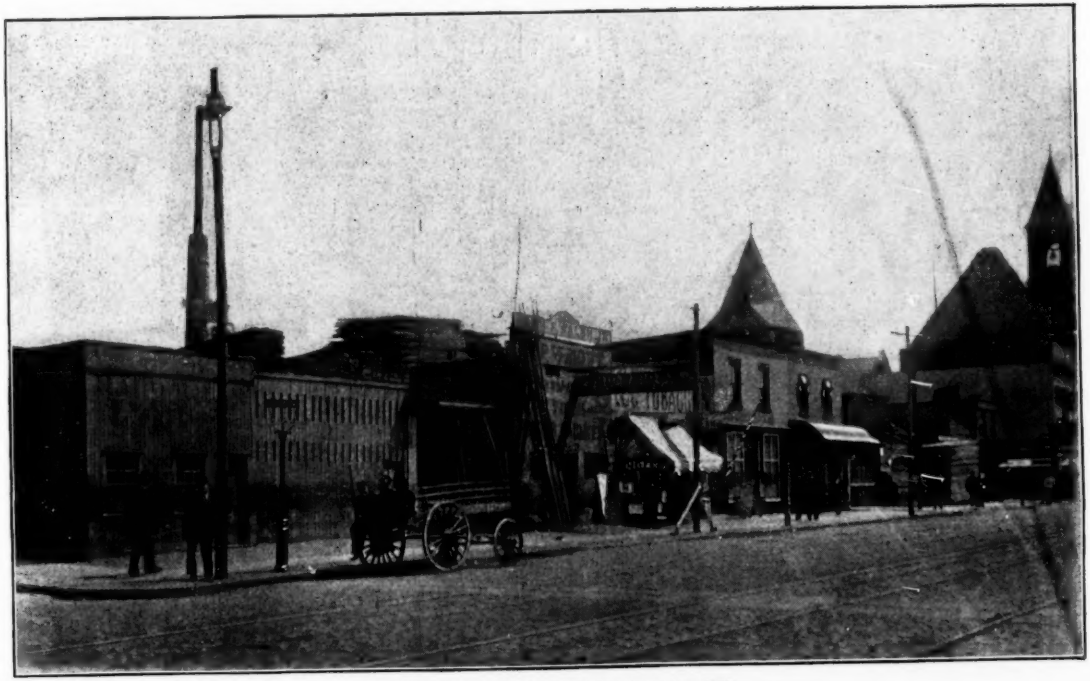
NEW YORK'S COMMERCIAL BLIGHT—II.

By William Nelson Black.

IN the preceding article it was seen that the municipal tenure of the submerged lands around Manhattan Island is an exclusively New York conception, due to the malign influences that controlled the early history of the city; that it could have been the fruit only of a blunder or a crime; that it has been productive of about the worst water-front system imaginable, a system that has converted the lower part of New York into a bedlam of blockading trucks, and driven the shipping that would naturally seek the city to Brooklyn and New Jersey; that it has made the lands along the water-front almost valueless, covering them with shells and rookeries that are a disgrace to civilization, and that, finally, it is threatening the city with an imminent commercial eclipse at the hands of neighboring cities that are sensible enough to observe natural and constitutional property rights.

All this was seen and maintained without much fear that my position could be successfully controverted. It chiefly concerns us now to know what we are going to do about it.

First, let us know what these submerged lands have been worth to the city. There is a popular impression that the property is very valuable. It ought to be valuable; and there is an improved section at the lower end of Manhattan Island about five miles long where we can find the data for an estimate. A portion of these lands have been alienated by the city, and now that she has discovered in the courts that these alienated sections cannot be recovered as they were originally obtained, by a simple process of seizure, she is trying to recover them by purchase. Here is one means of estimating values, and we know that single piers in the hands of private companies are rated at hundreds of thousands of dollars. This is a fair test of value; but it is not sufficiently comprehensive for the purpose in view. It does not cover the property of the city; and the gross rental receipts of the dock department will serve us better. We know that these receipts are now about $1,500,000 a year, a total which represents the interest at six per cent. on $25,000,000, approximately. It may not be thought quite accurate to estimate on gross receipts; but it is accurate enough

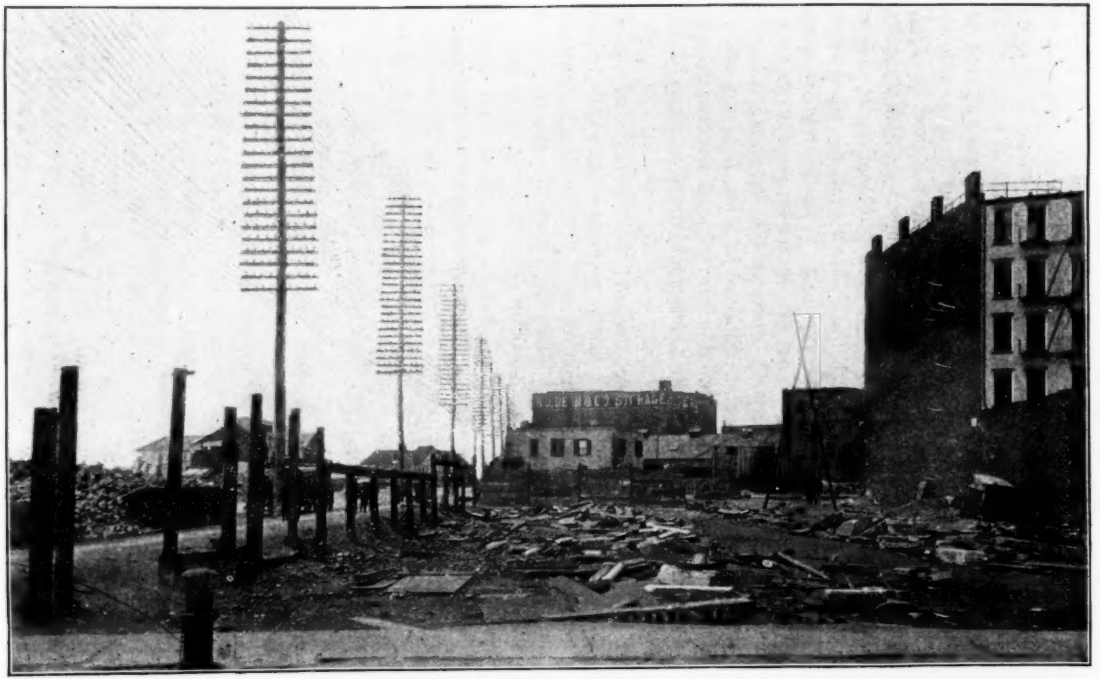


DRIVING PROSPERITY OPPOSITE NATIONAL-LINE PIER.

in this case. Call the value of the improved section $25,000,000 then, and add to this the value of the unimproved sections also in the possession of the city. They have a potential though dormant market value; and the total, improved and unimproved, may be roughly estimated at $35,000,000. Yet all that the city has ever drawn from this property in the form of net receipts has been about $100,000 a year. It is not drawing anything at this time. The balance is heavily the other way, millions a year, possibly, in deficit; but since the time when our Democratic and Republican friends made one of their effective little combinations to give us a good thing in the form of a dock department, the total receipts have been $15,000,000 and the total expenditures $13,000,000. This leaves about $100,000 net gain each year; and it has all gone into the sinking fund to help brace up the municipal debt. Can anything more ludicrous be conceived? Mind, it is the net gain from property with a potential market value of not less than $35,000,000 and which in private hands would unquestionably be worth very much more than this total.

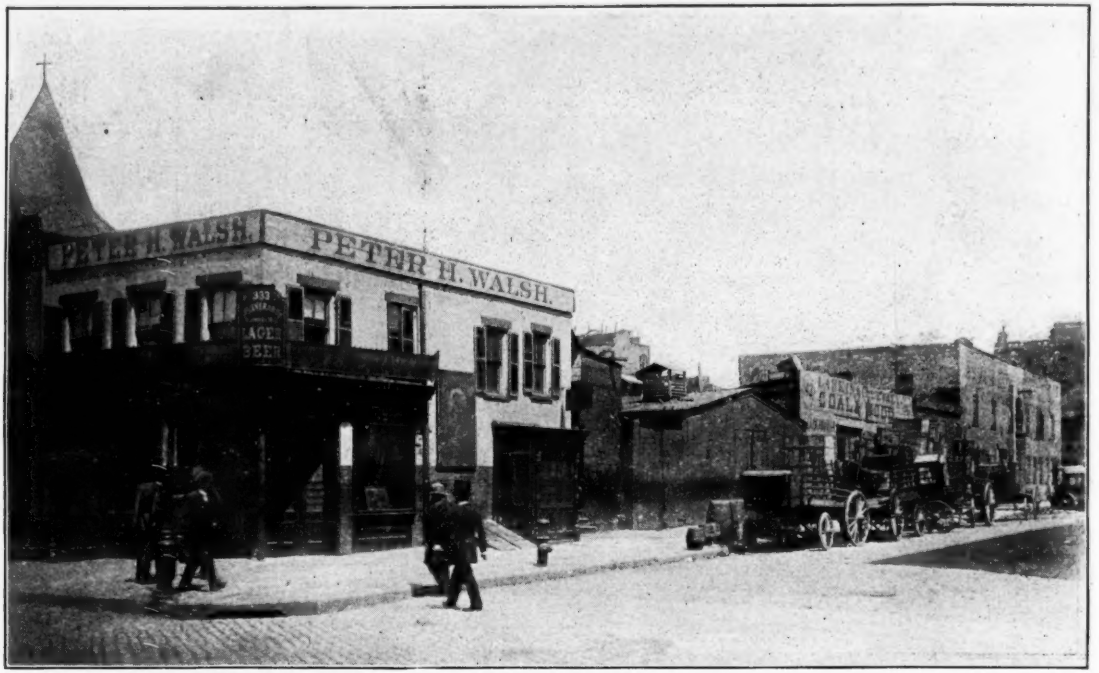
"But this is not a fair calculation!" exclaims the advocate of municipal enterprise. "It takes no account of the public improvements made by the dock department." No, it takes no account of any public improvements. The writer does not believe that the Almighty would admit responsibility for the creation of any man who is such a mental derelict that he will claim that the dock department has ever made any improvements. The few straggling platforms on piles over on the other side of the beach that isolates New York from her shipping are not improvements. No sensible man would think of calling them by any such name. The calculation is entirely fair. The munificent total of $100,000 a year is all that has been saved to the city from the proceeds of the submerged lands in her possession; and the remainder has been used to disfigure her features and promote her ruin. Even at present valuations the property in private hands would be paying about $700,000 a year in taxes. Directly and indirectly it would be paying several millions a year, for in private hands the increment not only on the submerged lands but on all adjacent lands, whether strictly repairing property or not, would have been several times the present total valuation.

Let us now consider the subject in its relation to commercial economy. Of course, it was broadly treated in this relation in the first article. A system that causes the waste of $50,000,000 a year



ACROSS THE STREET FROM WEST WASHINGTON MARKET.

[The condition—and not the theory—that has confronted us for five years.]



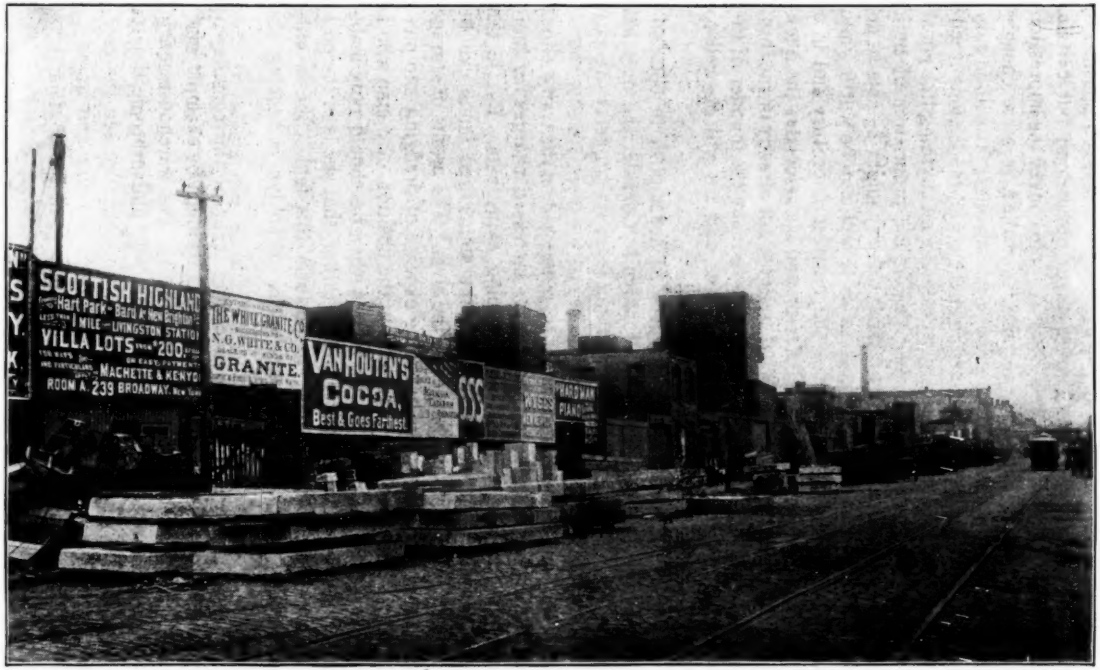
A WEST-STREET DISPENSARY.

A STUDY IN PERSPECTIVE.

in an abominable truck service is not entitled to much consideration when economy of any kind is under discussion; but certain callow and dishonest men are always trying to convey the impression that whatever is done by government, so-called, is more cheaply done than when done by individuals or companies. It will be easy to show that as the proprietor of the submerged lands alone it will be simply impossible for the city to compete on anything like equal terms with men who in adjacent cities are the proprietors of both submerged lands and uplands. What the city might be able to do were both properties in her possession it will not be worth while to inquire. So near the close of the nineteenth century and in a republic founded by Thomas Jefferson and his associates the question would seem irrelevant. What we have got already in the form of a dock department would be enough to make the founder of the Democratic party turn over in his grave, and we will do well to limit the inquiry to the existing system.

What, then, can New York expect to accomplish in competition with the warehousemen of Brooklyn? Consider the question of rentals. In order to draw anything from its property the city must impose heavy charges for the use of its piers, its only source of profit; and these charges must be reimposed on the traffic either in the form of charges for dockage or increased charges for merchandise, the final end of all recouping expedients. But in the hands of the owners of the uplands the submerged lands can be almost as free from all charges as the river. The profits of storage can cover the comparatively trifling expense of dredging and pier-building. New York at present is in the position of a man who is extravagantly maintaining two houses when he should only maintain one. It would be better to say, rather, that she is in the position of the man who is trying to perform this feat. She is only succeeding in maintaining one house. Brooklyn is keeping the other.

There can be no claim advanced in favor of the economy of the New York system. We are taught this much by example, even were the truth not so plainly self-evident. The warehousemen of Brooklyn are not managing their affairs with philanthropic objects in view. They know how to charge; and when we see the commerce of New York floating away from the city and going to Brooklyn, Hoboken, Jersey City, Bayonne, and Staten Island, we may be sure that the choice of economy is against New York and in favor of her rivals. This is so certainly true that we could look



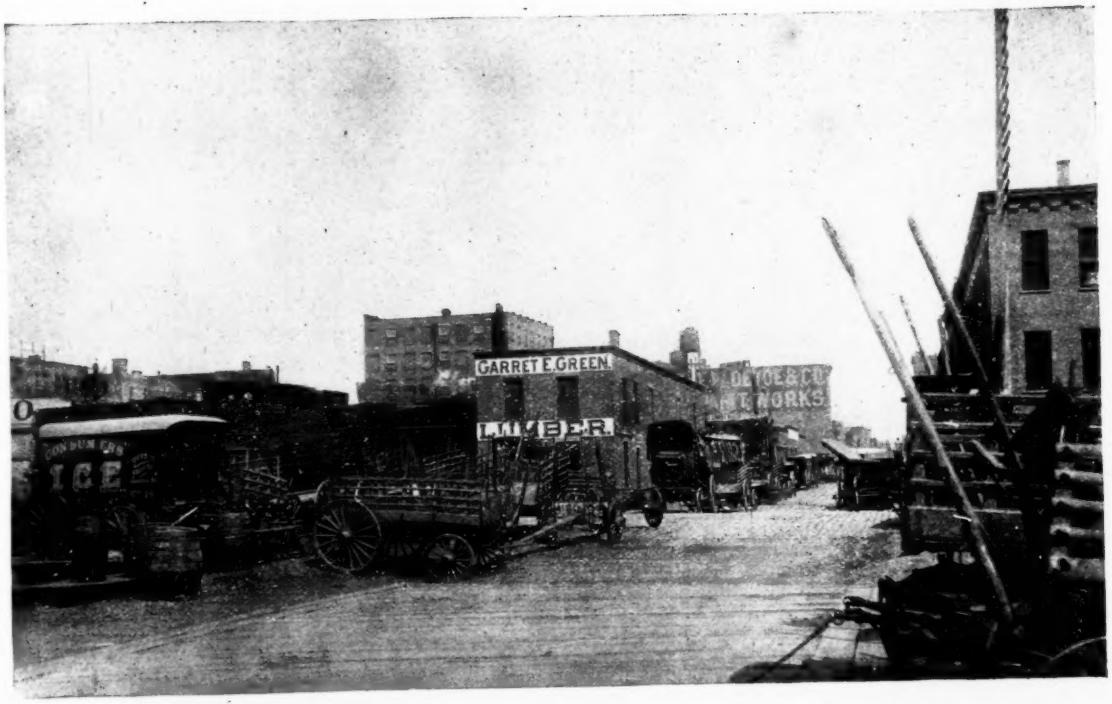
FOOT OF FOURTEENTH STREET—THE GENESIS OF A GREAT BUILDING MOVEMENT.

to see the restoration of riparian rights into the hands of the people of New York signalized immediately by a great reduction in port charges of all kinds. A reduction would be necessary, indeed, to enable New York to recover lost ground ; and for many years to come we may be sure that in a harbor where there is so much unimproved and cheaply available water-front as the New York harbor contains all charges would be held as low by the competing sections as they can be held profitably. No sensible man will wish that they should be held any lower.

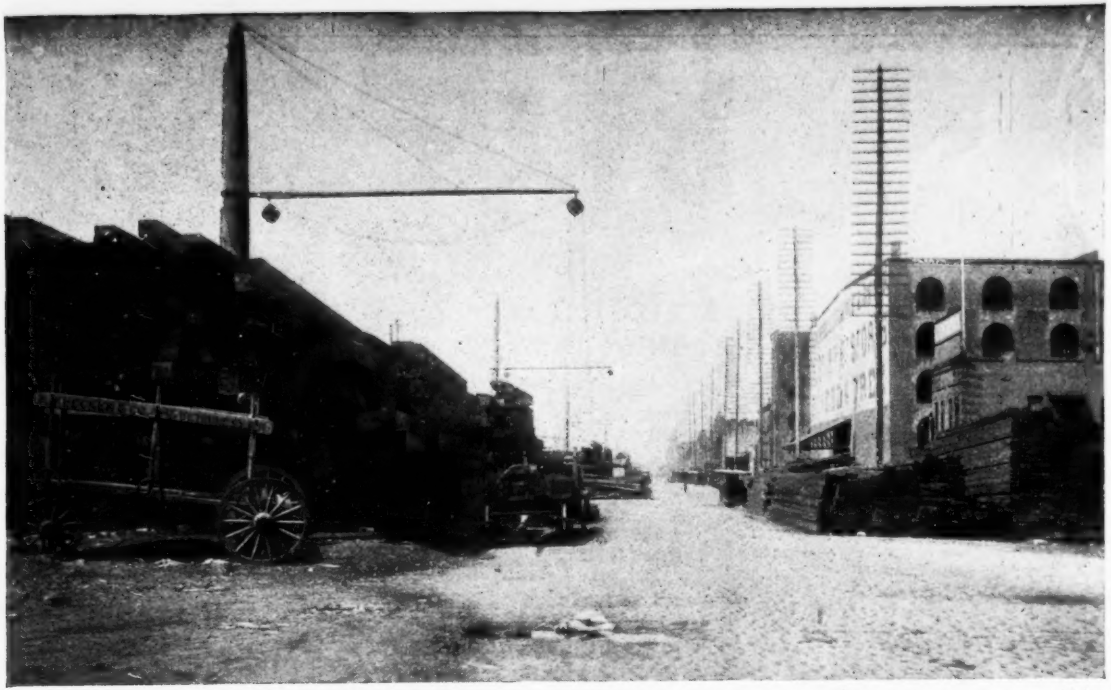
But, after all, this is not so much a commercial question as a question of construction and of local interests. The general public will be protected. Commerce will take care of itself, and it is taking care of itself by leaving the city as fast as it can pull up its roots and get away. But the city remains all the more humiliated and dishonored by the fact that her people once undertook to do a little in the way of construction that was thought at the time to look ship-shape and mercantile ; but which is proving to look like the pictures transmitted herewith to all readers of THE ENGINEERING MAGAZINE both near and far.

There seems to be but one alternative for New York and it is here. The political engineer must step aside and let the constructive engineer and the architect enter. The city has forfeited some of her commercial rights by a slumber many times more prolonged than the slumber of Rip Van Winkle, and her rivals have gained some rights which it is now too late to wrest from their grasp. But New York has still the right to check as far as possible the hegira of commerce from her piers, and to protect herself against the coming of a total eclipse.

Desirable events will follow upon auspicious conditions just as undesirable events must always follow upon malign conditions. As water flows along the line of least resistance, just so certainly will men act in accordance with their environment, and do what they find it most profitable and expedient to do. If it is desirable to have a rearrangement of the mercantile districts of New York, if we wish to see the wholesale warehouses and the factories located in juxtaposition to the water-front, an event to be followed by the abolition in chief part of the thrice-abominable truck service, and if we expect to find the rivers lined with storage warehouses, it will only be necessary to make the metamorphosis profitable, and, presto, the change will come. There are five thousand property holders in New York who are directly con-



TRUCKS CORRALLED OVER SUNDAY—THIRTEENTH AND JANE STREETS, NORTH RIVER.



FIRST-CLASS OPEN STORAGE-ROOM—THIRTEENTH AVENUE, NORTH RIVER.

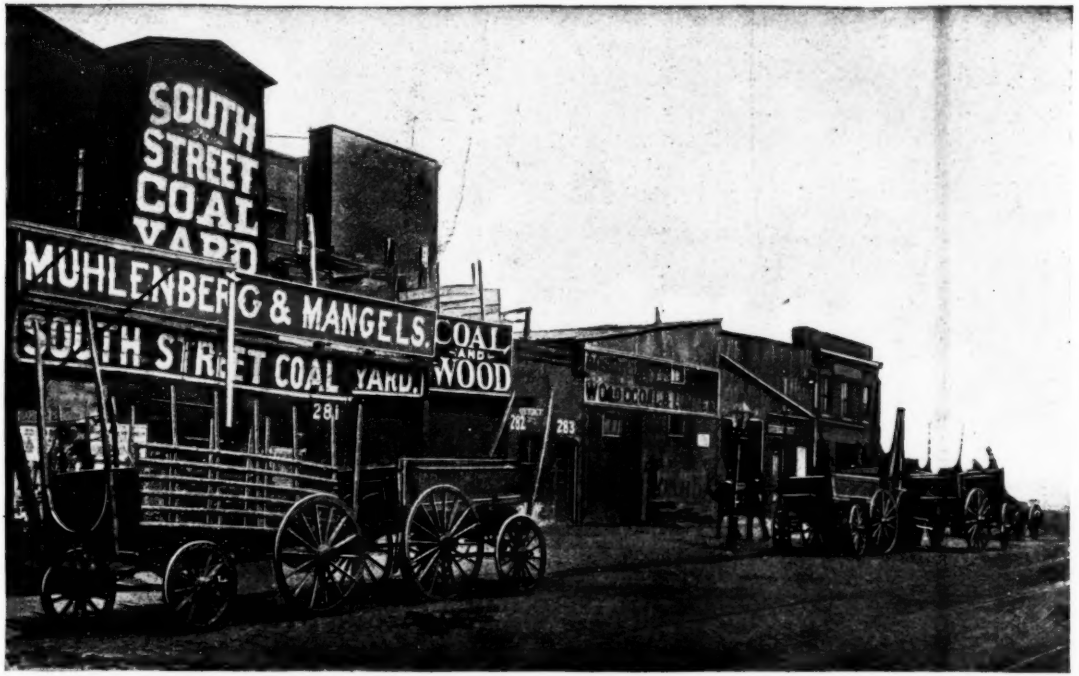
WEST STREET, FOOT OF KING.

cerned pecuniarily in the amendment ; and there are an indefinite number of engineers and architects who stand ready to execute a contract or commission with the utmost despatch.

But, first, the city must get out of the way. She must no longer exercise the time-honored functions of the river pirate in the spoliation of riparian estates. She must abandon those silly plans for exterior streets, or plazas, which are already beginning to make the borders of New York look like the disordered conception of some lunatic, and, at the mere cost of making the so-called improvements, or on the best terms obtainable, which ought not to be greatly above cost, surrender to the riparian landholders all pier franchises. This may sound like a very radical suggestion ; but it will be found a very profitable kind of radicalism for New York. It is the only step consistent with our political constitution ; and, the step once taken, amendment would be very rapid. The very step itself would add $100,000,000 to the value of water-front property and property adjacent to the water-front ; and the improvements to follow would quadruple on this amount in the succeeding ten years. The wholesale merchants want warehouses so located that the incubus of truckage can be removed, and the builders stand ready to supply them as soon as they can be supplied profitably.

Let us draw a pen picture of a possible New York, then, and print it on the reverse side of the pictures illustrating this article. It will bear but a slight resemblance to the photographic series, but it will represent a Phenix New York rising from the ashes of the old "Commonality" after the ghost of Dongan has been exorcised.

First, let us draw in fancy the scene along the water-front looking from the deck of an incoming ocean steamer as she sweeps majestically up the bay and river to her pier. There will be a wall of fire-proof warehouses, broken only at the street openings, all along the rivers in the district where traffic concentrates. These warehouses, six or seven stories in elevation, will rise from foundations placed at only a sufficient distance back from the bulkheads to give room for a double track tramway, with switches, and they will present to the eye of passengers on the water façades of most imposing design. But all their fronts will not be visible from the rivers. It will not be a single line of warehouses that will be seen, but blocks of warehouses fronting on three streets as well as on the rivers. Thus located, they may be used either for wholesale traffic



THE COAL INDUSTRY AT CLINTON AND SOUTH STREETS.

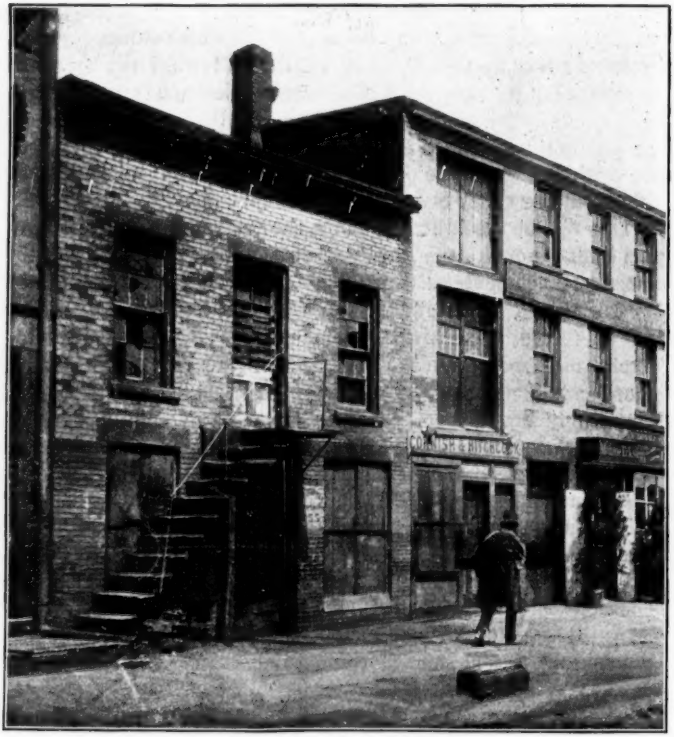
[Illustrating the Prosperity of the Coal Combination.

or for storage ; and in the area in the center of each block will be the place for the receipt and delivery of all merchandise. Trams, propelled either by electricity or cable, will furnish the means of transportation between these areas and all piers and railway freight depots. As to the piers they may be built either of granite or iron, and they will be shedded as now. But the roofs may be converted into platforms where the poor, whom we have always with us, may while away the sultry evenings of midsummer.

This will be the situation along the water-front of New York soon after the dock department has ceased its interference with the natural arrangements of commerce. The wholesale houses of the city will all be concentrated on the blocks nearest the water. They will be forced there by the demands of economy in handling merchandise ; and following their lead the heavier manufacturing industries will naturally gravitate towards the next interior blocks. They will be drawn there, like the warehouses, by the consideration of greater convenience and less cost. The tramways entering the warehouse blocks may be extended across the street into the areas of the manufacturing blocks, and they will give manufacturers all the facilities for long distance transportation provided for the merchants.

To some native New Yorkers, trained to familiarity with the conditions of a pigsty along the water-front, and hopeless of change, this picture may seem too much like Bellamy's dream to be a truthful presentment of coming improvements. But nothing has been delineated which may not be witnessed in partially-developed perfection just across the river, in Brooklyn. It would have been developed there in a high degree of perfection before this time had the people of Brooklyn ever taken it into their heads to engage in the wholesale traffic.

The picture is entirely natural, but it is not yet quite completed. A great transformation awaits the interior of the city when New York recovers from her lunacy and gets rid of the political engineer. It was the disorderly water-front system that caused the wholesale houses to invade the retail district down-town, and, with their auxiliary avalanche of trucks, to drive the retailers away from the center of population. It does not seem to be generally known that about two-thirds if not three-fourths of the population of the metropolitan district lies to the southward of Union Square, and that the really most central location for a retail dry-goods house would be still in the neighborhood of Chambers-street. Yet this is the fact; and as



A SPECIMEN RUIN ON SOUTH STREET.

the wholesale merchants vacate their premises along the lower part of Broadway, and the blocks adjacent to Broadway, their places can be profitably filled by retail merchants. It is not as far from Harlem to Chambers street as it is from East New York and about all Brooklyn and Jersey to Twenty-third street. Then, again, there is no good reason why all or nearly all the great hotels should be located miles away from the commercial center. They were forced to go up town for the security and comfort of guests; but a way will be opened for their return when the truck service has been curtailed. Indeed, the writer can conceive of a lower New York made so compact, comfortable, and free from all noise, filth, and nuisances of any kind that a new opera-house might be located on the site of Burton's old Chambers-street theater, could the location

be found. No such restoration of vanished glories need be anticipated ; but it is suggested for the purpose of showing how far New York has been pushed from her true equilibrium by the pernicious system that she is nursing.

The chief need of New York as a preliminary to amendment along the water-front is a little more of the fighting accomplishment. Her people fight doughtily on the defensive, a kind of fighting that generally leads to defeat. But they never fight aggressively if they can help it. It seems a little strange that about one hundred years should have been allowed to pass since confiscation was made unconstitutional in the United States, and that during all this time no person should have challenged in court the right of a colonial governor and a State Legislature to take without compensation the property of the riparian landholders of New York and give it to the city. Throughout Christendom, and as far back in history as the usages of land tenure can be traced, the title to submerged lands adheres and has adhered to the upland. Outside of the city, even the State of New York will not allow submerged lands to be granted to any proprietor except the proprietor of the adjacent lands. Then it seems to be about time that we should know whether or not in dealing with the people of her chief city the State is following a constitutional precedent which may have been made on the planet of Mars, but which is certainly not recognized in any other star in the American constellation, nor among any of the outlying nebula beyond the ocean.

INTUITION IN MACHINE-DESIGNING.

By John T. Hawkins, M. Am. Soc. M. E.

THE human mind is so constituted that successful endeavor in the various walks of life is dependent largely upon sundry tendencies or aptitudes, which are in great measure instinctive in character; and these peculiar mental traits lead their possessors into certain paths of activity corresponding to them, even against direct educational opposition to some extent. These tendencies continually assert themselves without special training or development and are always more or less perceptible in man's activities. They produce results, however, small in proportion as they are untrained and undeveloped; but under favorable environment and with intelligent educational nurture they are brought to such a degree of efficiency as we see exemplified in many of our great specialists in the various professions.

Among the useful tendencies of the mind, almost every one possesses some one or more which preponderates over or dominates the rest, and so far as the development of the man in mundane usefulness is concerned, it is a self-evident proposition that he is most likely to excel if the natural bent of his mind is followed in every preparatory and educational effort made in his behalf.

The tendency of modern times, under the vast field of knowledge which the acquisitions of the past presents to the student, is to confine a single man's efforts within a more circumscribed area, making of every professional man a more exclusive specialist; indeed this has become a necessity from the fact that no man now-a-days can possibly learn or "know it all," even when confined to a single recognized profession; and perhaps much of the unprecedented advancement made during the past century is due to the fact that specializing man's efforts has become a necessity.

Among the natural aptitudes which are peculiar to mankind and having distinct recognition as such are, for instance, music, painting, poetry, oratory, mathematics, etc. The possessors of either of these have an intuitional superiority in them, such that with proper training during the period of adolescence they must inevitably excel in the given field; where, if their training were directed to that which they were less prominently fitted for by nature, mediocrity is at best the result.

In the domain of applied mechanics there exists a faculty of the mind as pronounced and well-defined as is found among the spheres of activity above mentioned. It is best comprehended as Mechanical Intuition; and is intimately associated with what is known as the inventive faculty. While the two in fact combine to form that highest quality in the mechanician which leads to superiority in pursuit of his profession, the possession of the one does not necessarily involve the other, and we too often find the practical mechanician sunk in the more visionary inventor.

Those of us who are possessed of mental aptitude in mechanical matters are very generally adept students in physics, and it is but second nature to such men to comprehend Nature's phenomena and laws; but it is an unfortunate fact that a very great proportion of men who are naturally brightest as intuitional mechanics and natural philosophers have little of the purely mathematical bent of mind. It is unfortunate because the latter constitutes the most powerful lever by means of which the former is moved into place. That peculiar mental trait which enables its possessor to master the higher mathematics without difficulty—or what may be appropriately termed mathematical intuition—is rarely associated with either the purely mechanical or the inventive faculty to any great extent. Where they are combined, however, in the one man, we have potentially the highest type of mechanician and engineer; but in the more practical and material walks of applied mechanics the man is the more efficient and successful in proportion as the mechanical instinct preponderates over the purely mathematical.

Among the well-defined natural aptitudes indicated above, mechanical intuition has received the least recognition as capable of development through educational means, and it has long been the opinion of the writer that this particular trait should be more directly and assiduously fostered in our technical and other educational institutions than has been done in the past. While it must be patent to any one who gives the matter the least serious thought that, primarily, a young man who is most likely, from his natural aptitudes to excel, for example, as a musician, poet, painter, doctor or lawyer, should not be put in training to make of him a specialized mathematician or mechancian, but should be placed under a course of training in which—while including something of an elementary character in most of the paths he is naturally least fitted to follow as defining his profession—his education should be more directly aimed at the development of his natural bent. It is equally true

that, after the particular profession, or the particular institution to which he is to be sent, is decided on as best adapted to develop his natural traits in the general direction in which he aims, the same discrimination should be exercised within such an institution or course of study ; since in these days, even in a well-defined profession, no man can expect to excel unless he finally becomes more or less a specialist therein.

We have now numerous schools and colleges which have for their object the best course of preparation for the mechanical engineer ; and in these, while it is, of course, absolutely indispensable that the embryo engineer should have a fairly good knowledge of the mathematics, analytical mechanics, chemistry and other branches of the more general learning that constitute and are essential to his general equipment, the most prominent of all, and that which is most indispensable to him as a definitely specialized engineer, in most of the branches, is that his mechanical intuitions and inventive faculties should be fostered, trained and developed in every possible way.

It is of course understood that among the special fields into which it now seems to have become necessary to divide the profession of mechanical engineering—at least when practical life begins—there are some in which the more theoretical and analytical refinements of study are indispensable ; and toward which the student's efforts should have more special direction, and it is in exactly these that mechanical intuition may best be given a subordinate place ; but in a majority of the more or less special fields into which the profession is now of necessity divided, the former is the least and the latter the most important.

The point is that to produce the best equipped mechanical engineer—except in certain especially theoretical directions—something of those more abstract and general branches of study which go to make up the substructure upon which he must be built, should give place to an increased effort in the direction of educating, developing and training his mechanical and inventive instincts and intuitions ; without something of which latter no boy has any business at a mechanical engineering school. Now, for a large proportion of men, the foundation is unnecessarily broad, at the expense of the height to which the particularly designed superstructure might otherwise be safely raised.

It should require a very different training and course of study to equip a young man to become a professor of mathematics, of

chemistry, of physics or of mechanical engineering as a whole, from what is necessary for the production of a constructive and executive mechanical engineer ; and no one could object, where a boy exhibited a superior natural bent in the direction of either of these, to having him fitted therefor by every possible means ; provided he desires such a consummation as they lead to in directing his life-work. But to devote too much of his four years' course at school to the calculus, analytical geometry and similar groundwork to the detriment or neglect of that particular attribute of his mind which is most calculated, if properly encouraged and developed, to make of him a capable and successful mechanical engineer in whatever field he will ultimately cultivate, tends to render him an impracticable, at the outset at least, in the very walk of business life which he presumably chooses ; and—disavowing any desire to belittle in any way the grand work our technical schools have done and are now doing—it is the writer's firm belief that still better results may be had by so modifying the present courses of study at those institutions as to make them largely elective, and for such as exhibit the greatest mechanical and inventive turn of mind, to discriminate more in favor of encouraging, fostering and developing that to which he most decidedly leans.

Engineering, as a profession, in times past included all that is now placed under many heads : as civil, mining, military, electric, sanitary, mechanical and others ; these divisions being in the direction of the specializing made necessary by the constantly widening field of knowledge in those pursuits ; and in most of them there are now to be found subdivisions becoming as indispensable for the same reason. Among the several recognized general divisions of engineering none covers a broader field than that of the mechanical engineer ; and while that faculty which I have denominated mechanical intuition is essentially an aid to a man in either branch, it is, of all, the preëminent trait in which resides the potentiality of the mechanical engineer in the largest proportion of the many subdivisions into which it not only must, but is, now separated in practical life ; and it is that particular quality of the mind which should above all others be given the greatest prominence and most assiduous cultivation during his school days in any event. It would be infinitely better that a student at a mechanical engineering school should have that part of his course now devoted to the higher analytics supplanted entirely if necessary by some course of training which would be specifically devoted to the sharp-

ening and developing of his mechanical aptitudes, and expect of him that he acquire what he may finally need of them after graduation by a post-graduate course or otherwise than that it should be expected that he be invariably made proficient in them, as now, and be left to acquire that development of his mechanical traits which is so indispensable to him upon entering upon his professional career, almost entirely after graduation. The higher mathematics could be studied and acquired in post-graduate life by such as have a reasonable bent of mind in that direction with greater ease than can be obtained and mastered that particular but large factor in knowledge which comes under the caption of this paper; and it is infinitely more important to every mechanical engineering student to-day that he be as thoroughly trained as possible, in the time available, in all that I have described as mechanical intuition and inventive instinct, than that he should become an expert mathematician; unless his life work is to be devoted more especially to the theoretical than to the practical exercise of his profession.

It is not uncommon to find an alumnus of one of our mechanical engineering colleges, after two or three years of activity in his profession in a field not calling for the use of analytics to any great extent—and these fields are legion—quite ready to confess that, not only has he never had occasion to apply the calculus to the solution of a single problem, but that in so short a time, from this very fact of disuse, he had already become unable to apply it if it were needed; that he had so far forgotten it as to render the time devoted to it at school simply wasted; and it is equally notorious that many young men find themselves greatly at loss how to make themselves reasonably useful during the first years of practice of their profession.

There is no part of the extended field of mechanical engineering which calls for the exercise of mechanical intuition and inventive capacity to such an extent as machine-designing. There is scarcely a machine of any kind conceivable that may not be designed in a great variety of ways such that it may perform its functions or subserve its purpose more or less perfectly; while its efficiency, cost, durability and fitness in every way will be as various as these possible designs. It is the intuitional mechanic that will evolve the best design in a vast majority of cases rather than the man who is expert in the higher analysis; and there are few experienced mechanical engineers who are competent machine-designers who will not bear me out in saying that a very large proportion of

machines never require the aid of the calculus to give them their best and most efficient design and proportions; and that the application of that powerful instrument could not be of much, if any, effect in bringing them as near as possible to perfection.

Machine-designing forms so important and extended a part of the profession that what would seem to be most needed in mechanical engineering schools is a more definitely marked out course in that particular branch. The course in mechanical drawing now constituting a definite part of the curriculum should, of course, be an adjunct of this branch—and a principal one—but only an adjunct; while what should really be prominently a course in machine designing should include in a more or less extended way what the name implies. In such a course, machines and parts of machines should really be designed, and the same part or machine be designed in various competitive ways. Problems of the character, for example, of those recently given by Mr. Leicester Allen in the *American Machinist*, under the title of "The Cultivation of Inventive Capacity by the Solution of Constructive Problems," would be of the highest utility in exercising and developing the mechanical and inventive instincts upon which machine-designing so greatly depends. In these, a given motion is required; the problem being how best to effect or produce it. In such problems the students of a class would give as various solutions as have Mr. Allen's readers; and the exercise this would afford would be of the highest possible educational quality not only in the direction of machine-designing but in the making of a mechanical engineer in the more general sense. Making a study of constructive problems in some such way should in fact occupy the highest place and be given the greatest time in his education of any specific branch that can be formulated.

There is, of course no end to the extent to which this might be carried, quite to the detriment of the boy's more fundamental and general instruction; but exactly the other extreme is now pursued in paying too little attention or giving an insufficient prominence to the development of the mechanician and in consuming too great a proportion of his college period in refinements of the more general studies which he can very much better dispense with at the outset of his career in practical life, and more easily acquire afterwards than he can do without that which calls for the exercise of his executive and constructive capacity at the start.

The present system leaves the young man at graduation as an "M. E." in such position that, in a majority of his possible fields of

activity, little is to be hoped for from him in earning capacity (and for a large number of our young men this is a very serious matter) and is dooming many promising men, really capable of better things and deserving of better prospects, to a long period of subaltern drudgery which disappoints and discourages them to the last degree.

The kinematics of machines as given in the text-books now in use in the schools, constitutes a valuable branch of general study in the direction of development of mechanical intuition, but this kind of study of mechanical movements is too general in character to operate definitely in the direction of educating the inventive or mechanical bent, unaided by the more specific study of and exercise in constructive problems.

Shop-practice and instruction as now pursued is of the last importance ; but it takes hold of the problem at the extreme practical end only. It imparts an indispensable kind of instruction to be acquired in no other way so well ; and one which no mechanical engineering student should have less of than he now obtains at those institutions ; but between this and text-book kinematics—as particularly pertinent to machine-designing—lies the missing link which is wanting in the under graduate courses.

The study of kinematics as now taught is as essential in the course as either of the other fundamental branches, and shop-practice, within the limits of the school period—while far from making a skilled mechanic of a man—teaches him how the principal operations in the shop are best performed ; but a proficiency in both of these, added to the various fundamental parts of his general curriculum still leaves him—particularly as a machine-designer and executive engineer—without the ability to play such a part therein as should reasonably be looked for in a graduate. It should be a part of his curriculum to design some machines and invent others in a competitive manner, such as might be expected to properly subserve some predetermined purpose.

With a portion of the time now devoted to some of the refinements of mathematical and analytical study, exchanged for some such exercise in constructive problems as are pointed out above our young mechanical engineers would, in a majority of the possible fields of activity open to them, not only be able to make their start in life with greater promise of a career more profitable to themselves and to those in whose employ, or under whose direction they may be placed, but would ultimately make of themselves more efficient and capable men and engineers in whatever special field

they may choose, if they acquire in post-graduate or actual working life some of the desirable refinements above mentioned, instead of finding themselves obliged to begin at that time the acquisition of the ability to construct, execute, plan and invent.

The present error seems to be in making the curriculum more general than this specializing age will permit; failing to apportion the school period in a proper division of the kinds of study essential to the making of the student the most efficient and capable to enter upon such a specialized exercise of his profession as he must perforce decide upon at some time, and which should be decided not later than at the end of his sophomore year. After starting out, and taking this—to him—most important step in life, he finds no one making it his business to train him any further than he has gone at school. Bread-and-butter, or the means of getting it, stares the most of them in the face and they must dig the rest out for themselves, whatever that may amount to or consist of; meanwhile they, or he, not only feels, but in reality should be self-sustaining from that time; and he can better dig out, while self-sustaining, what I have indicated as desirable to supplant by a more direct training of his mechanical intuitions than that which is immediately required of him in a vast majority of instances.

No one can stop learning when he leaves school, and none should ever cease to be a student if he would succeed in life; and, since it has become quite impossible that the average man can acquire all there is of mechanical engineering, even in a lifetime, and the more completely any one man's efforts are specialized is he likely to be a success, both materially and professionally, the question only remains: what of his possible school studies is it best—in view of the particular field he aims to settle in—to leave to post-graduate study and for acquisition in after life while in profitable pursuit of his profession? It would seem that, as in so large a proportion of mechanical engineering work the exercise of mechanical aptitude and inventive skill is the first prerequisite, while in a very much lesser proportion the exercise of the more theoretical and purely analytical processes are found necessary, the courses of study might be made to more closely conform to these conditions than now obtain. In the present system between transcendental theoretics on the one hand and a modicum of "finger wisdom" obtained in shop practice on the other, there is a hiatus—a vacuum in which the mechanical engineering world seeks in vain for the men it mostly needs.

THE PROGRESS OF CREMATION.

By John Storer Cobb.

HOWEVER views may differ upon the proper manner of disposing of the remains of our departed fellow-creatures, the importance of the subject will be admitted by all who have bestowed upon it a moment's contemplation. It forms a serious factor in the problem of health, and in the solution of this problem every one living has a critical interest. The sanitary conservation of a community demands the early removal and disposal of its dead; but the method by which this is effectuated is scarcely less important than the existence of the fact itself. The law of nature ordains that our bodies shall return to their constituent particles so soon as they shall have become incapable of performing the functions of life. Many have been the contrivances by which the accomplishment of this disintegration has been sought. But however these may vary the result is in every instance the same. That dust shall return to dust is inevitable. In no way can we prevent the fulfilment of the decree. We may obstruct or we may assist; we may shorten or we may lengthen the time of the operation. That is all. But in this lies the whole distinction that exists between danger and security to those who survive. Every second consumed beyond the shortest time necessary to the proper and decent encompassment of the desired end constitutes an element of danger to the health of those who live after us.

Notwithstanding this, it is noteworthy that among the many different ways which have been contrived for the disposition of the dead, none, until recently, has had any definite consideration for the effect produced upon the living. When any special method has been devised it has been almost invariably with the idea of honoring the memories of those from whom benefits were believed to have been derived, or of degrading those whose lives were considered to have been sources of injury to their contemporaries. Most of these methods pertain to savage tribes and need not be considered now. The three methods in vogue among civilized nations are those of embalming, inhumation, and incineration. These may be described, in general terms, as an attempt to obstruct the process of nature, an indifference to the success of her

endeavors, and an essay to assist her in her work. This classification, however, presupposes in inhumation the direct contact of the body with the earth. By the intervention of casket or coffin, and the construction of elaborate tombs and vaults, the operations of nature are retarded and the evils of direct burial are intensified. We may therefore, by placing mummification and inhumation together, make a duplex division of our subject, and say that we are presented with the alternative of obstructing or of assisting nature. We are offered the choice of a putrifying or a purifying process—of disposing of our dead so that the living shall be injured or in such a manner that no harm may result from the operation.

The evils of inhumation, or burial in the earth, have been dilated upon so frequently that it would seem almost superfluous to say more about them, were it not for the fact that feelings of such strength and respectability are aroused when a change is proposed, and that education ever consists of repetition. Chemists and physicians of all schools and climes admit, I believe, that the mephitic exhalations from decomposing animal tissues are poisonous. They are fatal in their effects when entering, in a condensed form, into the human system ; and, however they may be weakened by diffusion, they inevitably lower the vitality of those who breathe them. Records exist of several instances of almost instant death resulting from the opening of graves and the removal of the bodies. The evidence is voluminous of reduced ability to contend with disease on the part of those who live in the neighborhood of graveyards, even where the use of these repositories has been discontinued for years and all bodies therein placed have been long since removed. It is not surprising, therefore, that the public mind has become agitated concerning the deleterious effects of crowding the earth with slowly decomposing human corpses, and that the cry has arisen for some other means of resolving these remains into their elemental components.

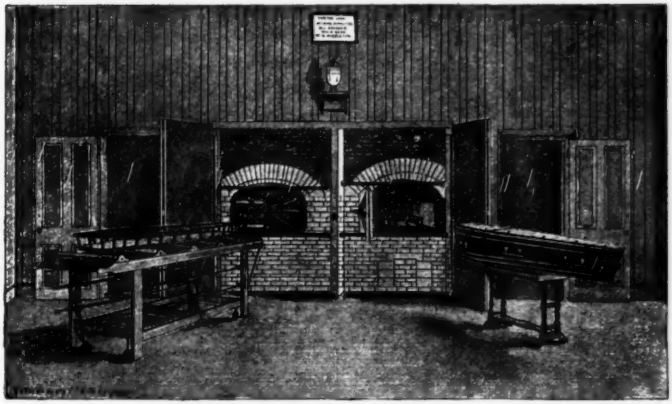
The earnest attention which has been bestowed upon the subject has resulted in the decision, on the part of many thinkers, that the general welfare will be promoted by the substitution of cremation for our present method of inhumation. The matter has been discussed ably by the advocates of each system. Many objections to the suggested change have been urged, but all of them appear to have been answered so satisfactorily that the theory may now be said to have gained a victory. There yet remains, however, on the part of many, a very strong prejudice against the practice of cre-

mation. This feeling is of such a character as to entitle it to the utmost respect and consideration, and it is so deeply rooted that nought but familiarity with the process, perhaps, will remove it. It may prove serviceable, therefore, to note the progress that has been made of late in the dissemination of the idea as well as in the practical application of the system.

It is only eleven years since the establishment of the New York Cremation Society, the first institution of the kind in this country, and not until the year 1885 was the first of our present operative crematories inaugurated ; yet there are now in the United States more than fifteen of these incinerators in more or less continuous service. In Europe, also, the growth of sentiment in favor of this practice has been very marked. In the number of crematories abroad Italy takes the lead, but there is scarcely a civilized country without one or more of these appliances in use.

The pioneer furnace of the United States is at Washington,

THE PHILADELPHIA CREMATORY.



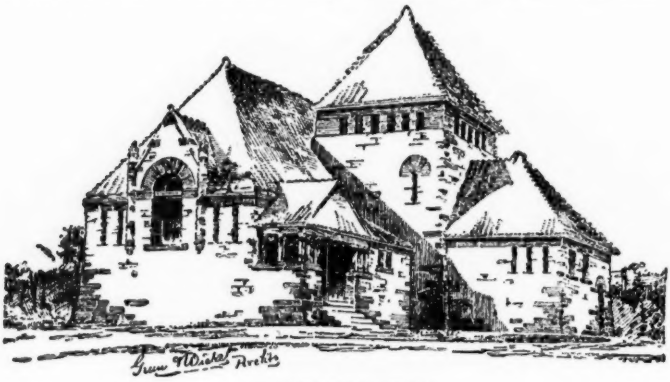
FURNACES AND RETORTS—LANCASTER (PA.) CREMATORY.

Pennsylvania. This was constructed by Dr. F. Julius Le Moyne, for the incineration of his own body. He was desirous, however, that in the meantime it might serve an educational purpose, and he permitted its occasional use, that the community might become gradually familiarized with the reform which he advocated. After his death, and out of respect to his wishes, his executors determined to admit for incineration the bodies of persons from all parts of the country, and thus help to keep alive the public interest in the matter. This was done until nearly forty bodies had been reduced to ashes in this crematory, and the demands for its services became so numerous as to interfere seriously with the regular business of the executors, when these gentlemen issued a notice that after August 1, 1884, they would be compelled to refuse reception to any bodies other than of those who had been residents of the county in which the building is situated. Since that date the fires have been lighted but once, so that we may regard the work of this avant-courier as in all probability practically ended.

This furnace does not make any pretension, of course, of taking rank with some of those which have been devised since its adoption. It is, indeed, somewhat crude in construction, and it takes too long to effect its object to permit of its design being ever brought into extended use. Yet it has done a most useful work and, by its propædeutic services in the cause, will be always entitled to honor from those who believe that the general good is

subserved by the substitution of cremation for burial as a means of disposing of the human dead.

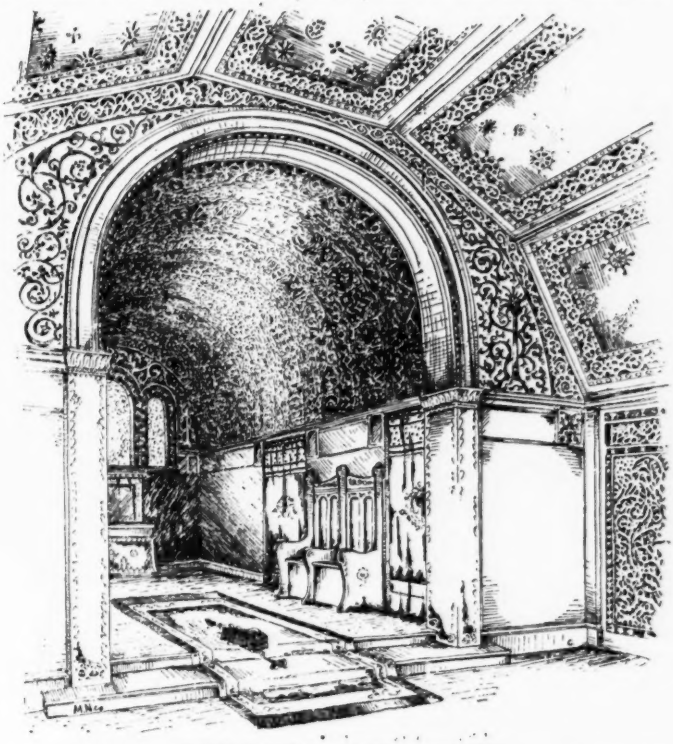
About the time of opening the above-named crematory an attempt was made to organize a cremation society in New York city; but, owing to a financial crisis in the business world about that period, and to the fact that public opinion in the Empire State had not yet sufficiently progressed, the experiment had to be abandoned. For nearly seven years no further steps were taken. Early in the year 1881 a meeting of advocates and sympathizers was called, and the occasion was considered favorable for a repetition of the endeavor with reasonable hope of success. It was decided to form two associations, one with the object of spreading abroad healthful information respecting the matter, and the other



THE BUFFALO CREMATORY.

for providing the means of carrying the idea into practice. The first was called the New York Cremation Society, and the last was designated the United States Cremation Company. The former has done, and is doing, valuable service in the carrying out of its propagandist objects and has also rendered substantial aid to its sister company in providing for the practical application of its tenets. The stock of the United States Cremation Company was taken slowly, and it was not until after the expiration of a considerable time that work upon its intended building was begun. Even then it did not proceed without interruption. Owing to accidents and other drawbacks its apparatus was not in working order until the year 1885, when the first incineration took place. Since then upwards of 750 bodies have been reduced to ashes by its means.

The furnace used was constructed from plans furnished by Professor C. J. Eames, and was perfected afterwards by Dr. M. L. Davis, of Lancaster, Pennsylvania. It is of fire-brick throughout, and separated into two distinct but similar compartments. The body is placed in a chamber directly above that in which the fuel is consumed. The bottoms of the retorts are solid, but the sides and ends are pierced with holes, by means of which the heated air



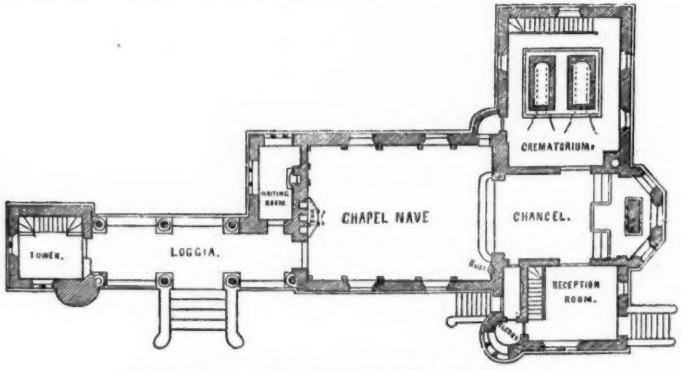
CHANCEL OF THE BUFFALO CREMATORY TEMPLE.

of the furnace has direct access to the body, while the flames are not permitted to approach it. The heat of the retort soon liberates everything volatile in the body, and these emanations are conducted through another highly-heated chamber and thus rendered odorless and absolutely innocuous before they find their way into the chimney which forms their means of egress to the air.

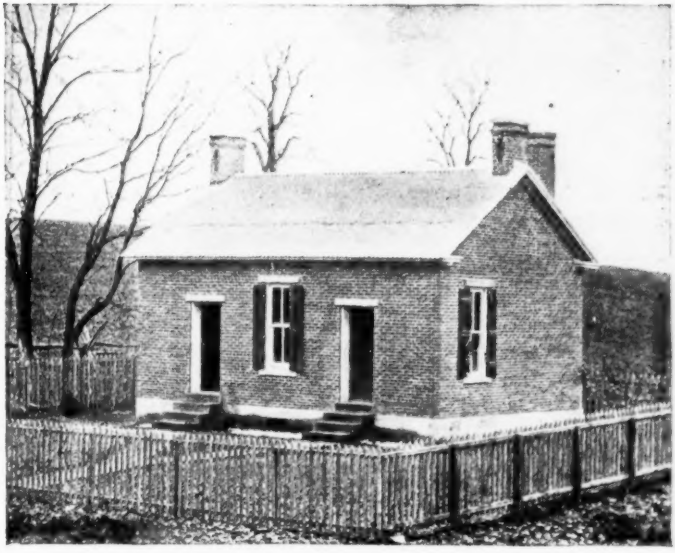
The time taken up in reducing a body to ashes depends somewhat upon the size and condition of the person when alive, and, in this furnace, averages about two hours. The fuel used is coal, and in five or six hours from the starting of the fires a temperature of from 2000° to 2500° F. can be obtained. The building, as it at present stands, is not a model of beauty, nor are the approaches to it the most desirable avenues of travel. For these things, however, the company merits sympathy rather than criticism. It has met with unexpected drawbacks in the prosecution of its work, but is now proceeding with commendable energy and judgment, and, it is hoped, soon will have its appliances in shape and condition such as were originally intended.

By the middle of the year 1884 interest in the subject had been somewhat extensively aroused, and at that time the Cremation and Funeral Reform Society of Lancaster, Pennsylvania, was organized, and the erection of a building was at once commenced. Work was conducted without interruption until the 25th of the next November, when the crematory was dedicated. It will thus be seen that, although this society was formed considerably later than the United States Cremation Company, it was somewhat earlier in a position to initiate operations. This, therefore, must take rank as the second crematory of the United States, and Pennsylvania must be regarded as the leader, in a double sense, of the practical movement on the western side of the Atlantic.

The furnaces and retorts are built from designs and plans originated by Dr. M. L. Davis. They are two in number, side by side, built of fire-brick and tiles made of the same material, fire-clay, red



GROUND PLAN OF THE GARDNER EARL CREMATORY, TROY, N. Y.

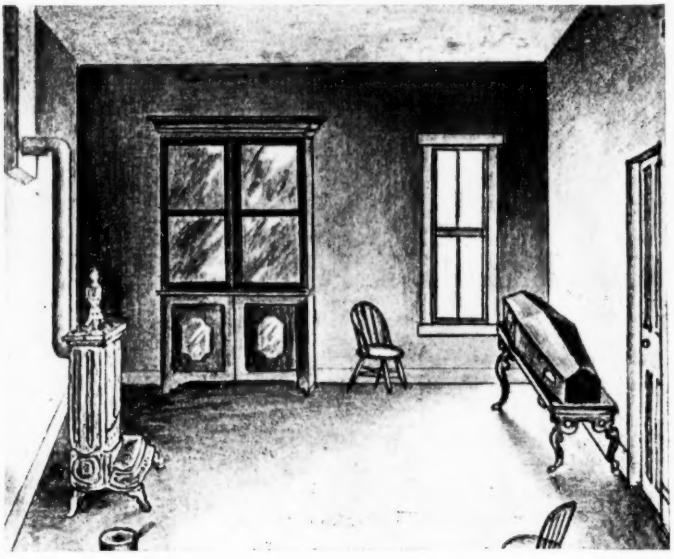


LE MOYNE CREMATORY, WASHINGTON, PENNSYLVANIA.

brick, asbestos, sand and iron. The retorts occupy the center of each furnace and the flues are constructed so that the heat encircles a retort three times before leaving it. The doors swing upon hinges, and are made air-tight by ground-joints and asbestos packing. The flue-chambers are faced outside with asbestos radiators, and protected by an expansion chamber. Before entering the escape-flue the gases from the body are compelled to travel through these flues, heated to a temperature of 2500°. Escape for any portion that has not been completely oxidized is thus rendered impossible. These furnaces can be heated in six hours, though a longer time is usually allowed in order to obviate the liability to injury through rapid expansion. Any kind of fuel can be used, and the time required for the incineration of a body is from forty-five to ninety minutes.

The subject has taken so firm a hold upon the minds of the Pennsylvanians that the directors of the Allegheny Cemetery Company resolved, last January, to erect a columbarium upon the company's property. This is built upon the hillside and contains one hundred niches or recesses for the reception of urns. The mate-

rial used is granite, and the style of architecture followed is, most appropriately, that of ancient Greece. There are five wide doors opening into as many compartments. The central or main entrance is that of the columbarium, and on each side are two vaults. The door opening into the columbarium is a fine specimen of bronze open work, through which a complete view of the interior may be had. The main entrance is supported by four massive pillars and adds much to the beauty of the structure. The doors of the vaults are of massive bronze, and each opens into a compartment for the

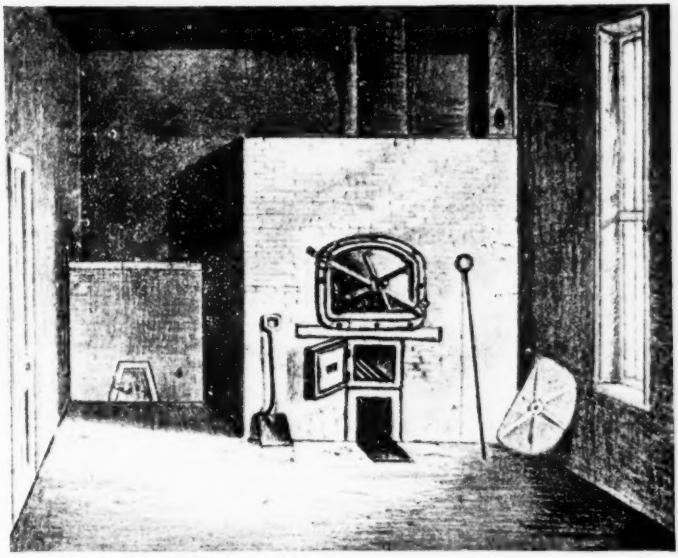


LE MOYNE CREMATORY—RECEPTION ROOM.

reception of urns. In the interior, which is finished in terra-cotta, are four tiers of recesses. These are so constructed that a tablet with an inscription or a plate-glass front may be placed in them, as the owners may desire. In the uppermost tier each space is separated from the next by an ornamental pillar, upon which rests the end of one of the arches forming the roof, which is in the form of a dome, and is finished in panels and arches of terra-cotta. The rays of the sun entering the apartment are softened by a stained sky-light. This is, I believe, the only building in the

world dedicated solely to the reception of human ashes. Since the times of ancient Greece and Rome no other has been erected for such a purpose. Our German cousins are about to build one in Berlin, but, so far, this in Pennsylvania stands alone.

In Pittsburgh is located a crematory in which, it is said, more bodies of prominent Americans have been reduced to ashes than in any other in the country. The furnace is situated in an undertaking establishment, and is also from the model of Dr. M. L. Davis, of Lancaster. Among the bodies cremated here may be



LE MOYNE CREMATORY—FURNACE AND RETORT.

mentioned those of Emma Abbott; Major McKee, commander of the Allegheny arsenal; and Professor Arbogast, a local musician of considerable note. This crematory is peculiar in being the only one in the world situated on a busy street in the heart of a great city and likewise the only one that has the advantage of natural-gas for fuel. It is noted particularly from this fact, and in foreign journals is always spoken of as the "natural-gas crematory." About seven or eight hours are required to heat the furnace to the proper temperature. Within one hour or one hour and

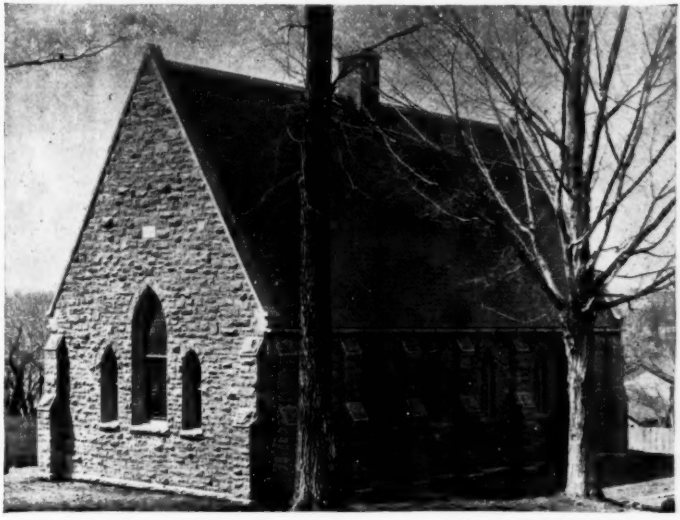
fifteen minutes after a body is introduced, nothing remains but the ashes. Not more than a few feet from the crematory is an apartment intended as a receiving-vault as well as for the temporary reception of urns.

In March, 1885, the second cremation company in the State of New York was organized at Buffalo, and in the following December the first cremation was conducted in the temple which, in the meantime, had been erected. This temple is built of dark-brown sandstone, and with its square tower and steep slanting roof, covered with ivy and surrounded by sloping lawns, reminds one of the small chapels built in the north country centuries ago. The chancel and the nave are decorated in early Italian style. Different symbols and devices are interwoven in arches of peacock-green and blue, and the windows are of rich stained glass. The incineration takes place privately after the funeral service has been brought to a close, and the ashes are delivered to the undertaker, to be disposed of as the family may direct; or they may be left at the crematory, where it is hoped a columbarium will be erected in the near future. The number of cremations which have been conducted each year in this building gives a very clear indication of the progress which the sentiment in favor of this method is making. It cannot be called, by any means, a rapid advance, but it is gratifying on account of the steadiness of the increase. During 1886 eight bodies were incinerated, and in each successive year to the end of 1891 the numbers were, respectively, 17, 16, 23, 30 and 37. The system in use here is that which was invented by the Italian engineer, Joseph Venini, and was first used at Milan. It is also in use at Udine, Padua, and other Italian cities, as well as at Troy, New York.

The building at Troy is, perhaps, the most beautiful, as it certainly is the most costly, structure of the kind in the United States. It stands in Oakwood cemetery, on the edge of a cliff three hundred feet high, overlooking the Catskill mountains and the waters of the Hudson. It was erected by Mr. and Mrs. William S. Earl, of Troy, as a memorial to their only son, who died March 3, 1887, after having become, while traveling in Europe, so favorably impressed with cremation as there conducted, that he desired his own body, at death, to be subjected to the same process. This was done at Buffalo on April 20 of the same year. The memorial is a magnificent granite structure, 136 feet in length and 70 feet wide, with a tower 90 feet high. It has been made a gift to the

cemetery company with the reservations that a place of burial shall be provided within for the members of the Earl family; that there shall be a uniform charge for cremation to all applicants; and that the chapel shall be free for funeral services to all owners of lots in the cemetery. The edifice contains two furnaces, placed beneath the room in which the retorts are situated; and, by a combination of gases, which enter the retort at different points, an intense heat can be engendered with the consumption of a comparatively small quantity of fuel.

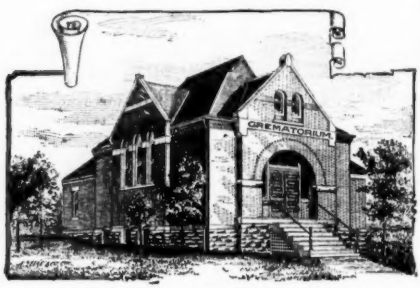
The year 1885 was very prolific of incineration appliances. Four societies were organized during this year, besides those already named. Of these the limitations of space preclude more than a passing notice here. The Michigan Cremation Association was incorporated at Detroit, but it was not until nearly two years afterwards that its crematory was put into use. This is a one-story, brick, stone-trimmed building, with a small turreted tower in front. Its chapel has a seating capacity of about two hundred, and the body is lowered, by hydraulic mechanism, into the basement, where the incineration takes place. The system is that of Dr. M. L. Davis, and after four years of service, during which



CREMATORY AT WATERVILLE, NEW YORK.

nearly eighty bodies have been cremated, it is pronounced highly satisfactory by the directors of the association. The Baltimore Cremation Company also found difficulties in the pursuit of its plans. Having become involved in litigation over the purchase of the land selected, it was resolved to connect with one of the leading cemetery companies, and land was bought in the grounds of the London Park cemetery. It was not until October, 1890, that the apparatus was complete and the first incineration took place. It still has to contend with great opposition, so that not more than twenty bodies have been reduced to ashes through its agency.

Although the Californians would seem to be, by a large majority, in favor of cremation as a theory, the San Francisco Cremation Company has not yet been able to raise enough money for the erection of a crematory. It has, however, now made such arrangements with the Cypress Lawn Cemetery Association as lead the directors to hope that, before the end of the current year, they may have one in operation. At present the bodies of those dying upon the Pacific coast, for which this method of resolution is desired, are sent to Los Angeles and there cremated. The crematory of the Northwestern Cremation Society, at Davenport, Iowa, was opened to the public in March, 1891, and has now reduced to ashes the bodies of ten persons. It is an attractive little building at one corner of the West Davenport cemetery. The retorts and furnaces are placed below the chapel in which the funeral services are conducted, and the building contains a room for the reception and retention of bodies, if any doubt should exist as to the death, or if friends desire that some time should elapse before the dead are subjected to the disintegrating heat.

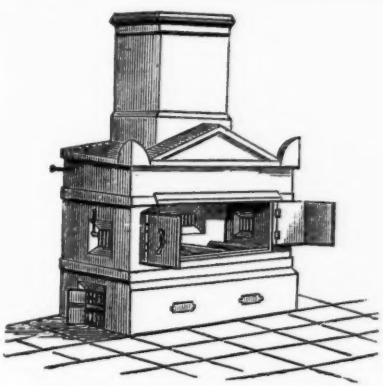


CREMATORY AT DAVENPORT, IOWA.

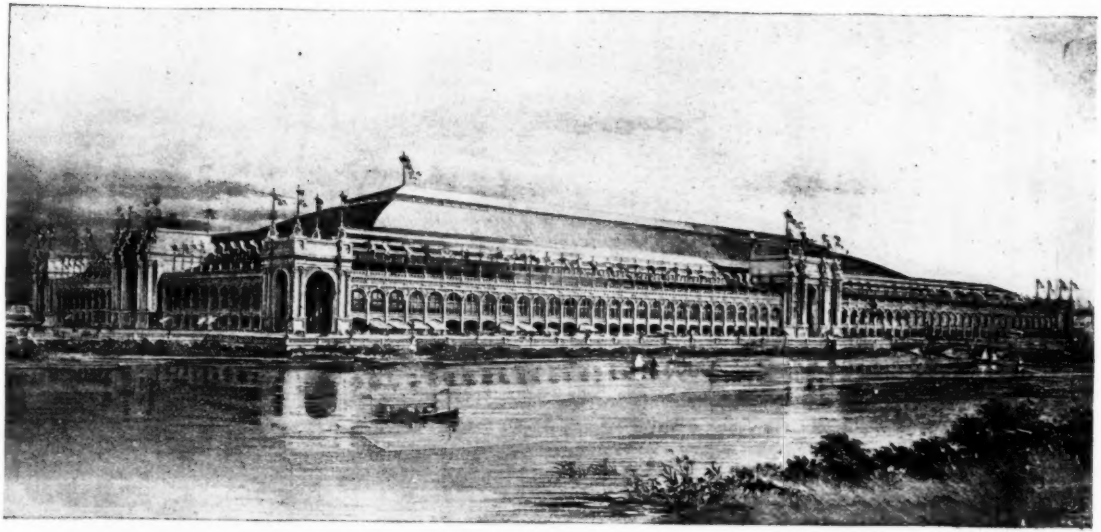
In addition to these the Philadelphia Cremation Society has a building in which more than 140 bodies have been cremated. This crematorium is erected in the Chelten Hills cemetery, and is provided with an extensive columbarium. Adjacent to the Municipal Hospital, the Board of Health has also established cinerary apparatus for use upon the bodies of paupers and hospital patients

who die of contagious diseases. The Cincinnati Cremation Company was chartered in 1884, but from unavoidable causes its building progressed slowly, and more than two years elapsed before the first incineration was therein conducted. The furnace employed is the construction of a local engineer, and upwards of 160 bodies have been subjected to the influence of its heat.

This brief and desultory account must be brought to a close with a few words about Waterville, New York. In the cemetery of this village has been erected a very pretty little Gothic structure, which has been presented to the cemetery company by Mr. William Osborne, one of its directors. It is supplied with a furnace and retort of the Davis pattern. It has not yet been used for the incineration of a human body, but tests of its powers have been made, and it is pronounced satisfactory in every respect. The erection of this building in a village cemetery, and the formation of cremation societies among the trades-associations of the country, mark a distinct epoch in the history of the subject. They show that the seed is taking root in difficult ground, and permit the indulgence of the hope that progress will be continuous until this system of returning our bodies to the dust of which they are formed will become the prevailing custom in civilized communities.



MANSTON CREMATORY, DORSETSHIRE, ENGLAND.



MANUFACTURES BUILDING, COLUMBIAN WORLD'S EXPOSITION—GEORGE B. POST, ARCHITECT.

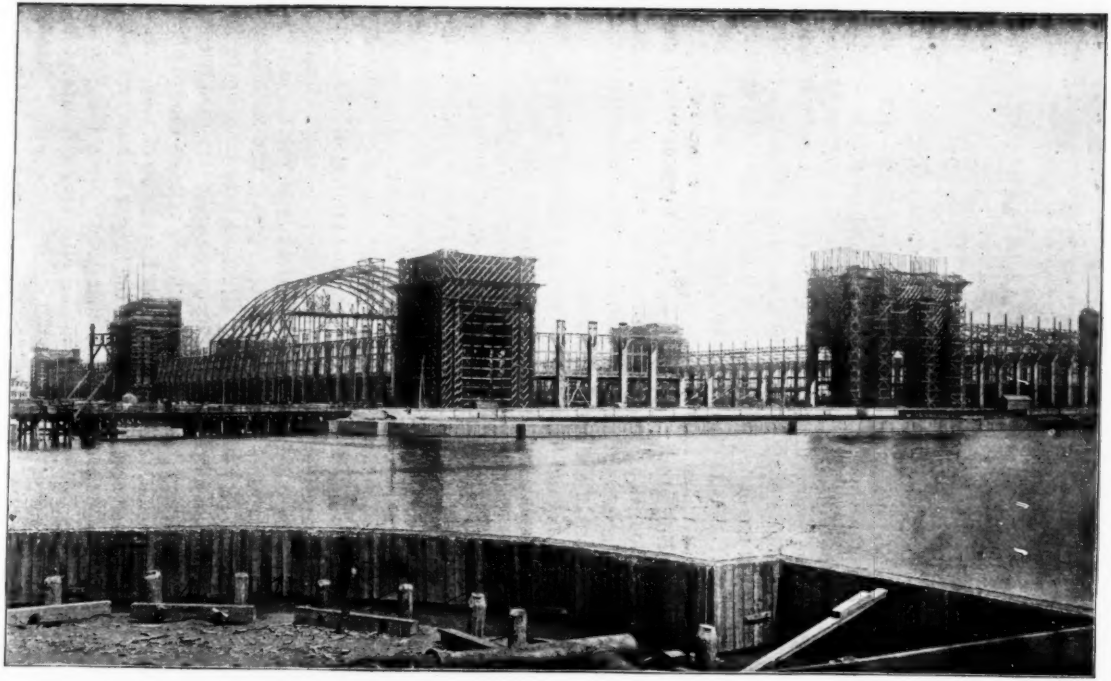
THE GREATEST OF ALL FAIR BUILDINGS.

By Joseph Kendall Freitag,

Assistant Engineer World's Columbian Exposition.

THE departments of Manufactures and Liberal Arts at the coming World's Columbian Exposition should attract the attention of the engineering world. Not only will the exhibits in these groups illustrate the history of engineering from its rudest beginnings down to the most modern improvements and inventions, but the building itself, which is to contain these exhibits, will be one of the greatest engineering feats yet recorded in history. Paris attracted the attention of all civilized nations by her monumental Eiffel tower, and now, not to be outdone by any previous exposition, Chicago steps forward with the largest building ever erected, as her special contribution to the wonders of the engineering record of the past and present.

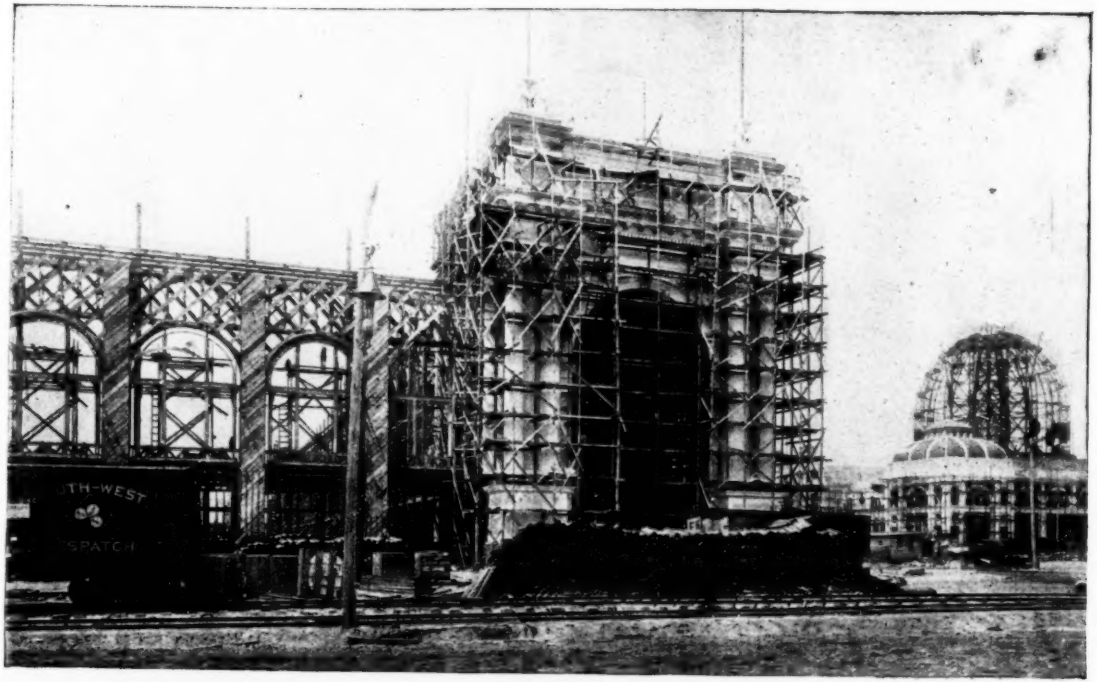
It is but natural that the exposition should give an impetus to the latent possibilities of architecture and engineering and become the foster-parent of such mammoth structures as have been seen at the World's Fairs of London, Munich, Vienna, Philadelphia and Paris; for the housing of such collective exhibits as are brought forward at national displays necessitates the covering of immense areas, both to suit the classification of the displays and to provide for the public convenience. London in 1851 exhibited a Crystal Palace which was 1851 feet long and 450 feet wide, containing 900,000 square feet of glass. The main, oval-shaped building at Paris in 1867 covered eleven acres, while at Vienna, in 1873, Machinery Hall had an area of nearly ten acres. The Main Building at Philadelphia was the largest structure ever built up to its day for exhibition purposes, covering only a trifle less than twenty acres of ground, and this was followed by the smaller, though more remarkable, Machinery Hall at the Paris Exposition of 1889, covering about thirteen acres by means of the largest arch or roof truss that had been constructed up to that time. Now, the World's Columbian Exposition, to maintain the progression instituted by previous exhibitions, provides a building so vastly beyond all preceding efforts, and of such engineering skill, that its proper description might easily be made to fill a volume.



MANUFACTURES BUILDING, LOOKING NORTHEAST, MAY 21, 1892.

The classification of the exhibits for the fair at Chicago falls into twelve groups: Agriculture, Horticulture, Live-Stock, Fisheries, Mines and Mining, Machinery, Transportation, Electricity, Fine Arts, Archæology, Manufactures, and Liberal Arts. Each of these groups is presented in a special building, with the exception of the last three, which are combined in the Manufactures and Liberal Arts Building. It is thus that we have need of such a gigantic structure, for in it are housed the subjects of Archæology, Ethnology and the Liberal Arts, comprising music, science and literature, besides all the products of leading industries not included within any of the other nine groups. This building occupies a most conspicuous position in the arrangement of the exposition grounds, lying as it does so near the waters of Lake Michigan, and separated from the gently-sloping stone beach, of over a mile's length, by only a broad avenue or promenade, along which are scattered booths and tea-houses of the various nations, intermingled with music-stands and floral displays. It is in the Corinthian style of architecture and severely classical in design. Its form is rectangular, 1687 feet long and 787 feet broad, covering a floor space of thirty-and-a-half acres. Its length is but a few feet short of one-third of a mile, while a walk around the building measures only 300 feet less than one mile. Including the floor space of the galleries, a total floor area of about forty acres is found in this building.

The structure consists of a central hall 1280 feet long and 380 feet broad, spanned by the largest steel arches ever built, rising to a height of 211 feet above the floor. On either side of this hall extends a gallery forty-six feet wide, then a continuous nave of 107 feet 9 inches span, and then an outside gallery of fifty feet. Projecting from these galleries are thirty-two bridges, fifty feet wide, crossing the nave, from which the visitor may view the sea of exhibits beneath him. The galleries are approached by thirty great staircases each twelve feet wide. The central hall has an area of eleven acres with not a single supporting pillar to interrupt this vast expanse. It is calculated that under this roof could be placed the Auditorium with its tower complete, and that six such buildings could be placed lengthwise in this inner hall of the Manufactures Building. Here, during the dedicatory ceremonies in October, seats will be furnished to 75,000 people for the exercises proper, and, on another day of the week of festivities, this vast expanse will serve as a ball-room for such a gathering as has probably never been seen before.

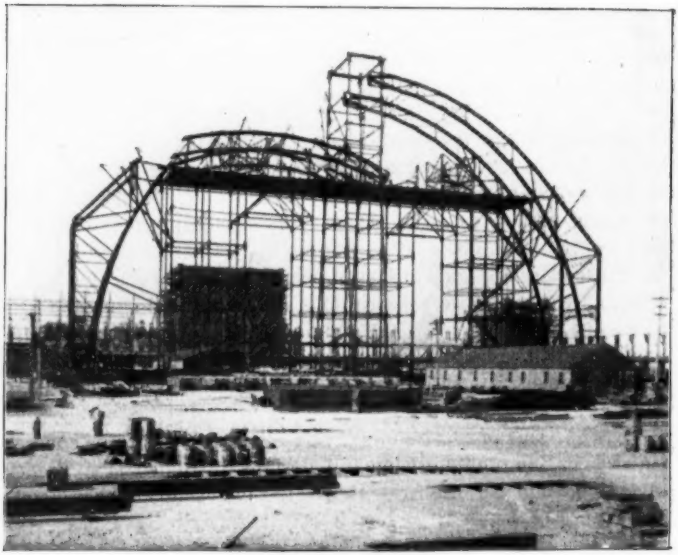


NORTHEAST CORNER OF MANUFACTURES BUILDING, JUNE 7, 1892.

"Columbia avenue," fifty feet wide, traverses the entire length of the hall and at its center is crossed at right angles by a street of equal width. Ornamental poles bearing electric lights will serve to light the various aisles and avenues in the building (as the exposition will be open to the public every evening), while large clusters of lights will be suspended from the roof arches to illuminate the whole interior. Some 20,000 electric lights will be used in this structure alone. Passing down "Columbia avenue" through one of the entrance portals and viewing the building from the outside, one will see a continuous series of huge arched windows, running along the four façades The lower portion of these windows, between the level of the ground and the gallery floor, is left entirely open, thus forming a cool, open loggia or promenade directly under the gallery floor, where the crowds can enjoy at once the view and the breezes of the lake and where nineteen large cafés supplied by hotel kitchens will administer to their wants. In the center of each façade is a huge main entrance in the design of a triumphal arch, the central archway of each being forty feet wide and eighty feet high. These portals will be surmounted by huge sculptured eagles eighteen feet in height, and above the side arches will be great panels with inscriptions and sculptured figures in bas-relief. The corners of the building are in the form of large pavilions with arched entrance ways, designed in harmony with the main entrances. Beautiful frescoes will adorn these lofty passage-ways.

The exterior of this building, like all the rest, is to be covered with "staff," in highly ornamental designs. "Staff" is a French invention, though it has come into extensive use in all the principal cities of Europe. It was employed largely at the Paris expositions of 1878 and 1889, though not to the extent to which it is used in our own exposition. It is composed of plaster mixed with New Zealand hemp cut in lengths of about six inches, to give the plaster body and make it fibrous. The desired ornamental work, be it a cornice, frieze, bracket, pediment or statue, is first modeled in clay by expert modelers. When the clay is hard, a pliable rubber-like mold is made from the clay model by means of liquid gelatine which hardens quickly. This mold can then be filled with the plaster and water, packed in with the hemp fiber, as often as that particular ornament is to be duplicated in the design. The plaster hardens in about fifteen minutes, when it can be taken out to dry thoroughly and the process repeated. These slabs, or orna-

mental pieces, are then nailed to the wooden furring of the building, the joints pointed up, and the whole given a coat of some external wash to produce the desired effect. The casts are of a milky white color, about one inch in thickness, and can be made to represent marble, cut stone, rock face or carving. Staff is both water-proof and fire-proof, and, if properly cared for, will last the average age of a house. An accompanying engraving represents a piece of ornamental staff-work inverted, which is to be placed between two of the window arches of the Manufactures Building.



BUILDING AN ARCH, MANUFACTURES BUILDING.

The roof trusses of this building are the largest ever built. They span 380 feet over all, rising to a height of 211 feet at the apex, the ventilating lantern bringing the height up to 225 feet; their width is fourteen feet at the base, thirty feet at the hip and ten feet at the apex. There are twenty-six trusses in all, each weighing 430,000 pounds, purlins included. They contain 1600 more tons of material than the Brooklyn bridge and 400 tons more than the Eads St. Louis bridge. More than eleven acres of skylight will be supported by them, or some sixty carloads of skylight glass.

There enters into the construction of this great work about 17,000,000 feet of lumber and 14,500,000 pounds of structural steel. The lumber represents the product of 1100 acres of average Michigan pine-lands. The foundations, not including the piles, require 4,600,000 feet of lumber and 3,000,000 feet, or more than 200 carloads, of lumber are used in the floor. It requires five carloads of nails to lay the floor alone. This floor will seat about 200,000 persons, giving each one more than six square feet of space, and, including the galleries, the building will seat 300,000 people, or the entire population

FOOT OF AN ARCH, MANUFACTURES BUILDING.

of Cincinnati. The standing army of Germany could be massed inside the walls, or, to compare it with our favorite American sport, six games of outdoor baseball could easily be played in it at one and the same time. The building is three times the area of St. Peter's Cathedral at Rome or four times the area of the ancient Colosseum. The cost of the structure will be $1,500,000. Its architect is George B. Post, of New York.

A word may be added, in conclusion, as to the nature of the exhibits in this building. The classification of the department of

DETAIL IN "STAFF," FOR MANUFACTURES BUILDING.

Manufactures falls into thirty-eight large groups, which are subdivided into more than 200 classes, including products of all the leading industries and latest inventions. The department of Liberal Arts in the south end of the building will fully present the advancement and present state of education and learning in all its branches—science, literature, music, religion, with all included therein. Archæology and Ethnology are for the first time to form a separate exhibit. The educational department will cover twelve acres, which is three times as much room as has ever been allotted

to it in previous expositions, so that the intellectual side of life will not be lost sight of amid the more absorbing practical displays. The department of Archæology and Ethnology will form one of the most interesting features of the entire Exposition. Here will be shown all possible traces of prehistoric man in America and the mode of life of the people whom Columbus found at the time of his discovery. Some of the phases of prehistoric existence will be shown by pictorial representations, others by skeletons of men and extinct animals, and still others by casts of all types of men in life-color and native costumes, together with a collection of the handi-work and arts of those primitive times, especially types of their architecture and ship-building. Much of this exhibit is to be obtained by new explorations, much from private museums. The whole department will be a most complete representation of the progressive stages of learning and civilization ever attempted, and will do justice to American research and advancement.

ENGINEERING OFF CAPE HATTERAS.

By Captain J. W. Walters.

FROM the first settlement of this country Cape Hatteras has been the bugbear of the mariner. Its very name has become a synonym for storms and wrecks. Fogs and the uncertain currents have carried many a brave man and noble craft to destruction upon the shoals surrounding the Cape. The Gulf stream with its fog-laden atmosphere sweeps by it in close proximity, forcing the navigator bound for a southern port to skirt the coast-line to avoid this current. But the demands of commerce are imperative, compelling the shipmaster to brave fogs and storms to make his port. Our Government has supplied without stint all the aids to navigation which it has been possible to devise, to guide and help those who follow this arduous vocation. But all appliances which so far have been placed in the vicinity of Cape Hatteras have proved inadequate to warn the navigator in time of danger.

Congress was petitioned recently, and with success, for an appropriation for the erection of a lighthouse on the eastern extremity of the shoals off the Cape. Proposals for the building were requested from responsible parties, the United States Lighthouse Board, having this matter in charge, only specifying the requirements and conditions necessary to the service, leaving the bidders to formulate their own designs. The contract was awarded to a reputable firm of constructing engineers, who at once began operations in the port of Norfolk by the construction of a caisson for the base of their design. Their labors were in vain. This caisson, constructed with diligence and care at an expense of thousands of dollars, was towed to the site of the proposed lighthouse and sunk, but one night of the ocean's fury overwhelmed and destroyed to the last vestige what had taken months of patient labor to construct.

History relates that a draper of London named Redyard designed and superintended the second lighthouse built on Eddystone. The principal material of this structure was wood, but it was planned so firmly that it withstood the gales and storms of this exposed rock for forty-six years, when it was destroyed by fire. Smeaton subsequently erected there the glory of his career. Here

is an instance of a dry-goods salesman showing the world how to build successfully a lighthouse upon one of the most exposed positions on any coast. Should the old saw, "Experience gained by failure," be repeated now in our case? No doubt this draper, Mr. Redyard, was a genius, but we do not necessarily require a genius for this sort of work. It is enough if he be one who will study diligently the natural conditions pertaining to the work in hand and make use of suitable means to accomplish any desired end.

We should think poorly of an engineer who would plan a foundation without a full knowledge of the material upon which or in which it was intended to rest. This knowledge is even more necessary in submarine construction than on land. One must study the currents and their action upon the bottom with varying conditions. The elements surrounding their locality and their action upon the proposed structure must be ascertained from a practical standpoint before one can draw deductions and formulate plans leading to a successful issue. Every case requires its own peculiar treatment in detail, but the experience of others on similar works will assist us in formulating a general plan of operation.

The conditions surrounding the locality off Cape Hatteras are these: It is the extreme eastern point of a sand shoal gradually deepening towards the Atlantic with about twenty-four feet of depth on the site selected. This lies about seven miles southeast from Cape Hatteras and is fully exposed to the ocean swell. The currents are changing constantly, their predominating direction and longest duration of flow being nearly north-northeast and south-southwest. The strength of these currents varies with the direction of the wind, the strength of the Gulf-stream current and its proximity, and also the tide-changes off this coast. No positive assurance can be placed upon their flow in any one direction for any length of time, by the best pilots of this locality. The sands on the shoal, like all sands on this sea-board, are changing their locality and depths within certain limits, caused by local obstructions and the currents and storms. A wreck often will change the conformation and depth of a shoal for a mile or more about it. The making of a sand island and its disappearance again are matters of frequent occurrence along this coast.

It is in a locality surrounded by these dangers that it is proposed to rear a shaft or column 150 feet high, inhabited by human beings, crowned with a light to guide the mariner at night, and fitted with a steam fog-signal which will blow its note of warning. All this

can be done in a manner that will be as safe and as permanent as anything made by man can be considered permanent. But to do this the ocean must be humored so that it will assist in the work.

The locality and conditions demand that a hold be obtained upon the site in the briefest possible period of time. A day, a week or a month are but seconds as intervals of time in the ocean's fury. One of our best known sea-captains proposed sinking old hulls loaded with ballast upon the site; but these would soon be broken up and scattered, their contents disappearing in the sands, leaving us in the same plight as before. Thousands of tons of stone dumped together promiscuously would disappear in the same manner, leaving hardly an elevation of a few feet to mark their deposit. One of the conditions demanded of the successful bidder is that the foundation must be solid and massive, that its base must be sunk to a stratum underlying the surface of the shoal, which offers sufficient resistance to the weight of the structure. Should this stratum consist of material which can be scoured or displaced by the sea, it must be deep enough below the latter to be out of all possible reach of the destructive action of the water. This requirement certainly will give an assurance of permanency to the structure. But to obtain such a foundation we must sink a caisson, and every attempt of this kind in an open seaway would be futile, as was demonstrated by the previously mentioned effort. Our first effort therefore is the erection of protecting works.

Research develops no precedent for this case, but there are many experiences similar enough in their salient points to supply deductions applicable to it. The old saying "The Dutch have captured Holland" is certainly true in the sense that it has been a war with the ocean for centuries, which is being waged still and manfully maintained. And what has been their weapon and armor? Not stone walls and iron breastworks, but brush—the simple, pliant willow-brush—growing in abundance where nature most demands it, in moist and sandy soils. This same abundant material has formed the groundwork upon which many of those noble piers and moles of Europe's seaports have been built. It is with a fabric of willow that we can lay a lasting foundation in these sands off Cape Hatteras, and induce the opposing elements to assist us to fortify the site against their own attacks.

Willow-bushes for this purpose are compressed into long bundles called fascines. Mattrasses constructed with these fascines were used by Captain Eads in the construction of his jetties at the

South Pass of the Mississippi. He used them successfully to induce scouring in the channel by the river current, and in the present case they can be used with equal success to induce silting and thus create an island. The willow by nature is elastic and possesses beyond any other brush-wood the quality of continuing its growth by transplantation. Even when submerged, as in a fascine-structure, it will throw out fibers in all directions, and thus quickly form a self-sustaining living mass of vegetation. The interstices of the fabric induce silting of the sand or mud with which

FIG. 1—VERTICAL CAISSON ON LOOSE GROUND.

the water is loaded and accumulates this material within and around its body with the greatest rapidity. The greater the agitation of the water, the more rapid is this accumulation ; and in this manner it soon becomes a fixture capable of supporting enormous masses of heavier material.

Before proceeding to a design of a fabric for our purpose let us study more fully the conditions. We have varying currents whose maximum strength is estimated at four knots per hour at

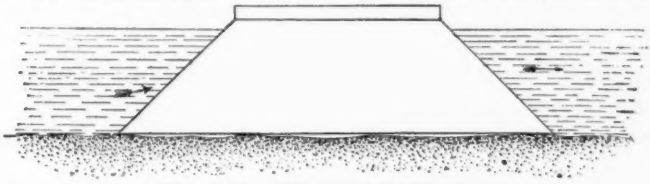


FIG. 2—SLOPING-SIDED CAISSON ON LOOSE GROUND.

times. What should be the shape of a structure to withstand this current and its action upon the ground? Figure 1 will illustrate a vertical caisson after being sunk on a sandy surface. The current impinges upon its vertical sides with great force, seeking a path around the obstacle. The impact creates a disturbance of its even flow, when the dense masses near the bottom at once begin the scouring process at the base of the structure in their endeavor to pass beneath the obstacle. A cavity is quickly formed, which

rapidly increases until the equilibrium of the structure is destroyed and it collapses. Figure 2 represents a conical caisson resting on the same ground. In this case the impact of the water is minimized. Its sloping side deflects the current upwards and away from the ground material, thus neutralizing the tendency to scour. In fact the eddy behind the structure will silt the material upon the base, which formation eventually will extend around the whole structure. This application is comprehensive in its conformity with natural laws, and is found in all noteworthy submarine constructions. Smeaton founded the Eddystone lighthouse in imitation of the trunk of an oak, its base in the same manner sloping upward. Our design therefore should conform to this shape.

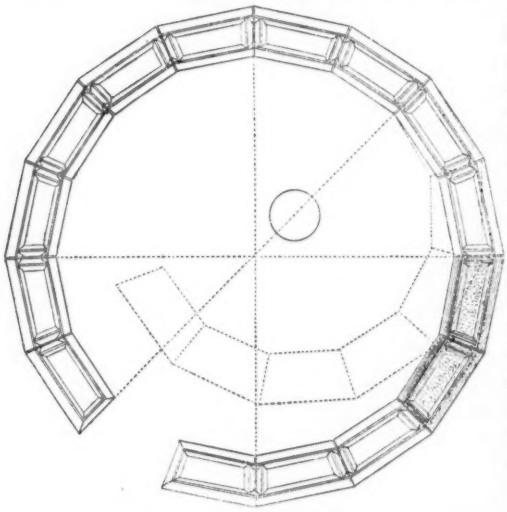


FIG. 3—CIRCULAR BREAKWATER.
[Consisting of 15 fagons chained to each other. The circle within shows the position of the Lighthouse.]

The next condition requiring our consideration is the exposure to the heavy ocean swell. A rigid, solid material would be easily destroyed by the action of the swell before there would be time to support and hold it in its position, but an elastic and porous fabric will withstand similar attacks for a much greater length of time. Nature teaches us in this respect a valuable lesson. All submarine plants are filmy or porous and bend to the waves to save their existence. Therefore, a structure possessing those qualifications will outlast more substantial materials until we have obtained a foothold against the attacks of the sea.

In the execution of any design for this work we certainly have the advantage of our forefathers in calling steam power to our aid,

and accomplishing what would be next to impossible without its use. It enables us to transport a great mass of material regardless of wind and tide, and so expedite the work, which is of the utmost importance. Figures 3 to 7 are designed to illustrate the foregoing deductions and demonstrate more clearly the practicability of the application of willow fascines for this work. Figure 3 shows the outlines of a circular breakwater with an opening at the least exposed side. Figure 4 illustrates the same style of structure except that one end is drawn spirally within the other, with sufficient breadth between the ends to permit the passage of a vessel. The extreme diameter of either of these structures at the base-line would be about 600 feet. Each is composed of fifteen sections or separate structures, built up of willow fascines of which Figure 5 is a plan. Figure 6 is a cross section in elevation, and Figure 7, a part of a longitudinal section in elevation. These are sufficient to the present purpose of illustrating a construction which can be sunk on the site and fully ballasted in from eight to ten days from the time of leaving port. In order to do this we need no particularly skilled labor. Our maritime and seafaring population can furnish a class of laborers that will understand fully all the requirements.

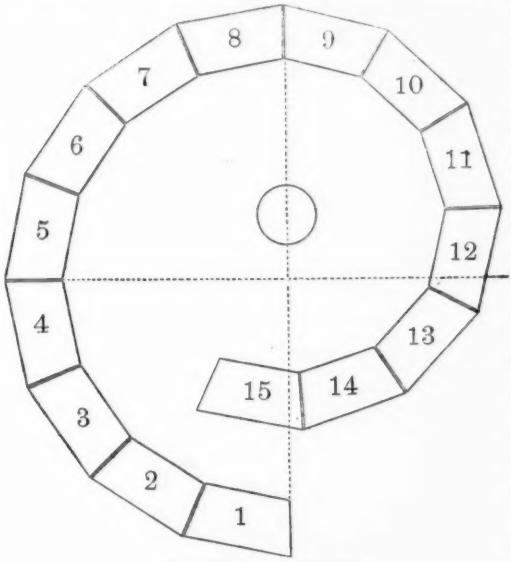


FIG. 4—SPIRAL BREAKWATER.
[Showing the number of each Fascine.]

There are three particular shapes or fabrics constructed with fascines for submarine work. One is the plain mattrass, Figure 8,

as used in river-works where the current is in one direction. Then comes the cone-top mattrass, Figure 9, for tideways and coast-works, which forms a substantial backing for rip-rap. Last is the *façon* or box-shape of which Figures 5 to 7 give a general idea, and which are more applicable in the deeper waters of the coast and tide-ways.* It is of the latter shape that we must avail ourselves in this case. Although more expensive to construct it is the most economical in ballast, which is thrown into the cavities of the structure and there held against the action of the waves. It is applicable especially in quicksands and places subject to varying currents, and we have only temporarily to guard against the breaking away of parts of the structure before silting is completed to

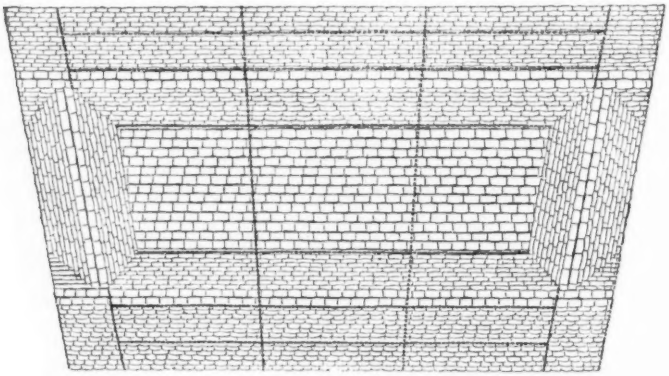


FIG. 5—PLAN OF FAÇON SHOWING THE MANNER OF CHAIN-TIES AS THEY APPEAR ON THE OUTSIDE.

insure permanency to the work. I have therefore adopted a series of chain-ties to bind the fascines in addition to the regular fastening by pegs as ordinarily used. Figures 6 and 7 give a fair illustration of this application of chains and anchors. The number of these can be increased to suit the emergency. They will give flexibility to the structure and still hold its parts, sufficiently long for our needs, from breaking away in a seaway. The silting sand will accumulate with the greatest rapidity and soon make it self-sustaining.

These *façons* can be built afloat, or ashore on ways similar to

* A certain latitude in the modification of these designs can be exercised by engineers to suit the requirements of the conditions surrounding the site of the works to be constructed. The design of the façon illustrated here conforms arbitrarily to the present requirements.

shipways and launched in the same manner. I consider the latter the cheapest and most reliable mode of construction. When all the sections are completed and afloat, they should be ballasted sufficiently to bring them to the lowest line of flotation permissible with the depth of water in the harbor where constructed. They are then connected one with another in the rotation of position they are to occupy in the completed structure, as in Figures 3 or 4, when they are then ready to be towed to their destination. I estimate that it will require 40,000 tons of stone ballast to sink and load this structure to eight feet above low water. About 8000 tons of this will be required to ballast the sections in harbor, leaving the remainder to be transported by barges to the site. These should be in readiness at the port of departure to be towed out to the structure as demanded.

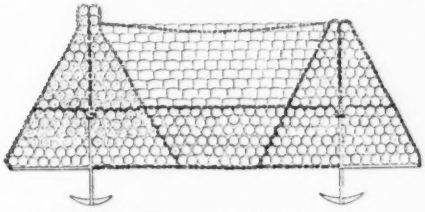


FIG. 6—CROSS-SECTION IN ELEVATION OF FAÇON.
[Showing the manner in which the chain-ties intersect the structure and hold of mushroom anchors.]

So far all the work has been in a safe harbor or ashore. We now await the right time, when westerly winds prevail, which is usual in the spring, when we prepare the site for the reception of the structure. This will necessitate the mooring of a series of anchors encircling the site, the chains trailing towards the center with suitable buoys to mark and assist in picking them up. The anchors belonging to the two end sections are not planted, but have been suspended to their respective sections, ready to be dropped when necessary. These naturally will come on the western side as the least exposed, and it is through this gap in the moorings that the tow will approach the site. We are now ready for operations at sea.

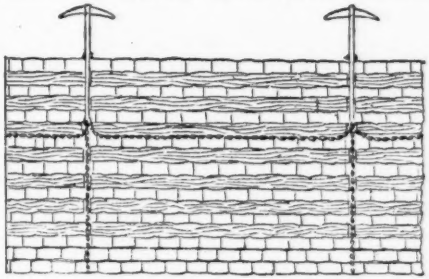


FIG. 7—PART OF LONGITUDINAL SECTION IN ELEVATION OF FAÇON.
[Showing manner of connecting chain-ties to each other.]

When the right moment has come six ocean tugs will be well

able to tow this structure by attaching their hawsers to sections 7, 8 and 9—the three middle sections—the others trailing astern in two lines. Simultaneously we tow a sufficient number of barges, holding about 15,000 tons of ballast, with other tugs to the site where they are anchored. The tow approaches the site from the westward where the end sections are to be moored, and when within the circle of moorings the tugs will spread the structure to its required shape and assist in picking up the moorings. The anchors on the end sections can then be dropped and the ends towed towards one another. Before these ends are closed, a number of barges have been moored within the circle of the structure and begun the discharge of the ballast. The end sections when closely enough advanced toward each other are connected and held there by hawsers, and barges moored to them at once which will sink them quickly and free the hawsers across the passage for a clear entrance to the circle within the structure. Tugs can then take out the unloaded barges and replace them with others as they are required. As this ballast can be of such a size as to be handled by hand, it will depend entirely upon the number of men employed to determine the length of time required for its discharge. It is safe to say that facilities and men enough can be furnished to advantage to discharge 1000 tons per day out of each barge.

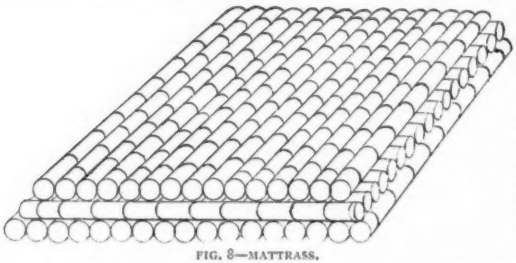


FIG. 8—MATTRASS.

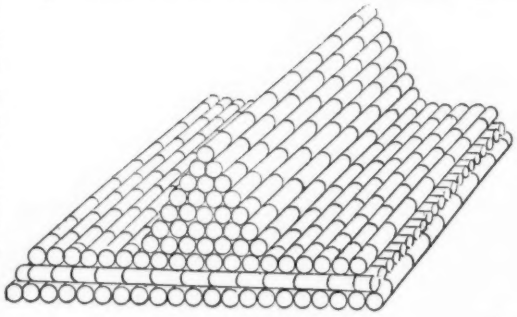
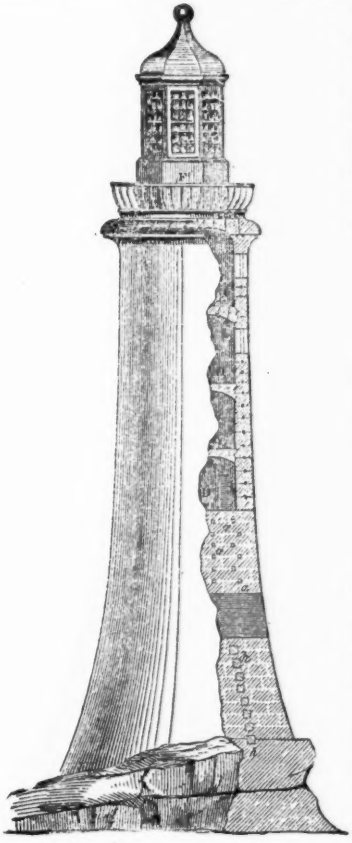
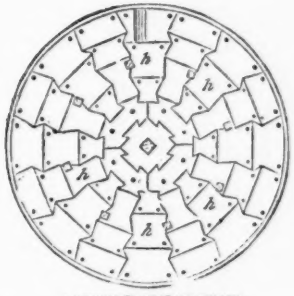


FIG. 9—CONE-TOP MATTRASS.

So much for the procedure. The effect obtained is this: Estimating with due allowance for contingencies, which I am very much overestimating, the tow will occupy eighteen hours from port to site, and ten hours for mooring, during five hours of which six barges have been ballasting the structure. We moor one barge additional to each end section, which makes eight barges ballasting the structure the first twenty-four hours. Each section will require 500 tons of ballast more than it received in port to sink it securely to the bottom. This is 7500 tons which these eight barges can discharge readily during the first twenty-four hours with the additional five hours during process of mooring. We then have secured during fifty-two hours from port a quiet and safe basin, wherein the barges can continue their work uninterrupted even in the face of a gale of wind. But 25,000 tons of ballast yet remain to be discharged. With five barges working continuously this can easily be accomplished in five or six days more, when our work is completed and a haven of complete safety is secured, wherein the construction of



SMEATON'S EDDYSTONE LIGHTHOUSE.

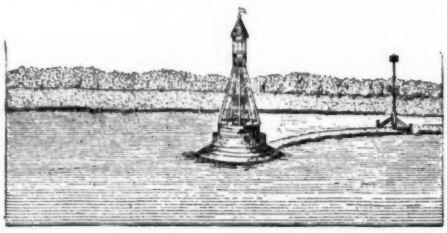


A LOWER COURSE OF STONE.

[Showing manner of dove-tails and joggles by which the work was closely barred together.]

this light-tower can proceed with impunity, making an ordinary engineering enterprise out of what appeared an impossibility.

Let us now inquire into the contingencies of failure. The most critical time during this operation is during the process of mooring and the first two days of ballasting. A moderate sea-swell will not interfere with us. It is the easterly gales we would have to fear during this time of operation. It is fortunate that we have a prevalence of westerly winds during the spring. Sailors aver that by choosing our time of departure we can confidently expect three days of continued westerly weather. Let us choose such a time for our departure and proceed. If as the tow approaches the site the weather threatens to storm, the signal for return to port is given to await another opportunity. Should the storm break out before the return there will be nothing to fear, as the structure in the condition of a tow will outlast any craft afloat, and will fare far better than many such tows of barges along this coast. Or should we have our mooring completed when the weather should begin to storm, we will have a number of barges within the circle continuing and concentrating their efforts upon the weather sections of the structure. The remaining barges have been anchored to leeward of the structure and also can have hawsers attached to it. The tugs in the meanwhile have their hawsers fastened to the weather sections and are steaming ahead with sufficient energy to hold the structure to its moorings during the continuance of the gale. These are operations not at all difficult or risky ; but on the contrary far less dangerous than many feats this class of men are called upon to perform during each year. In this description I have endeavored to show to practical minds the feasibility of the enterprise. Old pilots of this section have assured me that during the prevalence of westerly winds this part of the sea is sufficiently smooth for weeks to conduct these operations with perfect safety. And we only need three days of passable fair weather to insure success.



SWINEMUNDE LIGHTHOUSE AND MOLE, BALTIC COAST OF GERMANY.
(This lighthouse is built on sandy bottom in 23 feet of water, 1½ miles from shore. It is exposed to the full force of northerly gales sweeping across the Baltic. In winter icepacks will pile against its base with terrific force, often overlapping the mole. Its foundations are bedded upon fagons.)

THE GOLD-FIELDS OF SOUTH AFRICA—II.*

By Gustave Hallé, Asso. Mem. Inst. C. E.

THE eastern Transvaal gold-fields may be described roughly as a semi-mountainous tract, some ninety miles north and south, by fifty miles east and west, fairly equally disposed around its chief mining camp, Barberton, a town lying about 25° 46′ S. by 30° 6′ E. The average altitude of the district may be taken as 3000 feet above the level of the sea, and the height of the highest of the innumerable ranges by which it is traversed as not exceeding 2500 feet more. It lies at the foot of the great central plateau of South Africa, known as the high veldt, and consists roughly of a large oval plain, known as the de Kaap valley, and the broken and irregular masses of hills surrounding it on three sides. This plain is a treeless expanse, some eighteen miles by thirty-five in extent, bounded on the west by the broken fringe of the high veldt known as the Drakensberg, on the flat tops of whose highest summit lies the alluvial district commonly called the Duivel's Kantoor; on the south and east by the ranges of hills known as Moodie's, the Sheba, etc., extending south, as the Komati and Swaziland gold-fields; and on the north by irregular masses of somewhat lower hills known as the Jamestown and North de Kaap districts.

The Kantoor, a flat barren region some 5800 feet above sea-level, divided from the high veldt by the valley of the Eland's river, rises precipitously above the de Kaap valley and is reached from it by roads which for dangerous grades and general badness should boast few equals. This arid waste is dotted over for the greater part by heaps of enormous circular stones, apparently piled on one another often to a height of forty feet, frequently as much as thirty feet in diameter. The peculiar appearance of these stones, combined with the undoubted fact that gold, liberated by the disintegration of the friable sandstone of which they are composed, had frequently been picked from their interstices by traveling Boers and transport riders, earned them long ago the name of the Devil's counters and the whole region that of the Duivel's

*The first article of this series appeared in THE ENGINEERING MAGAZINE, Vol. II., No. 5 (February, 1892).

Kantoor, or Devil's counting-house. Except during the rainy season, from December to April, this region is a waterless wilderness. The huge depression, the de Kaap valley, lying at its foot, on the eastern edge of which the town of Barberton is located, is entirely floored with granite and traversed by innumerable deep water-courses. The immense masses of water pouring over the edge of the high veldt every flood have cut up the apron, at the foot of the Drakensberg, into the most marvelous labyrinths of precipitously-sided gullies, often from 100 to 200 feet in depth, and, from their narrowness, more worthy the name of chasms.

To the early Dutch hunter, skirting along above the valley of Death, as this vast circular plain was grimly called, this great network of mist-filled depths and waterways seemed to resemble nothing so much as some mysterious city. Cape Town, de Kaap (the cape), being the synonym with him for the biggest thing in this line on the known earth, the valley received the alternate name of the de Kaap valley—the valley of the great city. Under cultivation and grazing, and perhaps the consequent destruction of rank grass and weeds, the evil reputation of this valley has entirely faded away; the Barberton district is certainly semi-tropical, and very different to the high veldt in climate, but it is by no means unhealthier than other localities of similar latitude and altitude.

The auriferous ranges to the north, south and east, constituting the real gold regions of the district, are singularly lovely in appearance. The district seems at first view fraught with every advantage that could be desired for a flourishing community. The climate is magnificent, and not unbearably hot. The de Kaap valley water-courses converge into two or three considerable streams, uniting at a point about opposite to the Kantoor and flowing, under the name of the Lampoguano, down between the Sheba and Jamestown ranges, to join the Krokodile river on the Lebombo flats, and the various auriferous ranges contain innumerable smaller streams. These are, however, owing to the general steepness of the hills, little more than mountain torrents, almost dry for the greater part of the year, and of limited value for mining purposes. The limitation of water power to the larger streams, combined with the abruptness of the hill formations, and consequent difficulty of transport, have been the chief causes of the disparity between the excitement prevalent at the first discovery of the richness of these fields, and the slowness of their later development.

Geologically, the formation of the Kantoor belongs to that of the flat-lying beds of the high veldt, and consists of white friable sandstones, assuming fantastic shapes in weathering. These sandstones in disintegrating have liberated nuggets, although the beds themselves cannot be economically worked in mass. These beds overlie others of quartz conglomerate similar to those of the Randt, and these in their turn rest directly on the de Kaap granite. These conglomerates are auriferous, and it is believed payably so. These sandstones and conglomerate beds are broken through by greenstone dykes, which here also occur as intrusive sheets, emanating from the parent mass. A large number of small fissures of no great extent have been formed in these dykes, presumably by contraction on cooling ; and these have been filled subsequently with vein quartz, containing comparatively a large quantity of gold. These feldspathic rocks are at present all decayed to considerable depths, and this quartz now exists only as fragments that have been washed and distributed over the surface by atmospheric agencies. As a consequence its contained gold has been liberated and is now found as so-called alluvial. Only a small proportion has found its way into the creeks, and, as was to be expected, it is found in practice that all the nuggets are at or near the surface, as they are of insufficient weight to penetrate to any depth in the clay material resulting from the decomposition of the eruptive rocks. It is further to be noted that all this gold is, as at Lydenburg, crystalline, and therefore at once distinguishable from water-worn alluvial. The granite of the northern portion of the de Kaap valley is also cut by a number of gash-veins of slight depth, containing often a large percentage of gold and presumably to be found payable on washing out in mass. Except for a moderate quantity discovered in the creeks among the Jamestown hills, no true alluvial has been found anywhere throughout the de Kaap valley.

The north, east and south sides of this large granite area are flanked by tilted shales, sandstones, quartzites and conglomerates, (the latter on the south only) which in all cases dip away from the central mass, and have a strike, roughly speaking, tangential to it. These rocks extend to the eastward for a considerable distance, and to the west either disappear entirely or are overlaid unconformably by the flat-lying rocks of the high veldt. To the south, they extend to the northern part of Swaziland. The average dip of these shaly rocks, which, however, are in part schists, may be

taken at about 80°, and it is among them that the auriferous deposits of these eastern gold-fields lie. These rocks are broken through throughout this district by greenstone dykes which, though generally following the strikes of the beds, sometimes break through them at every angle ; and it is a fact that gold is always found associated, in some as yet scarcely understood manner, with these dykes.

The auriferous deposits found among these rocks may be divided roughly into three classes. First are segregated veins which follow both the dip and strike of the enclosing strata. These are composed generally of dark blue, occasionally of white, amorphous quartz, in which the gold occurs to a great extent free, or native ; though below water-level pyrite is found, which gener ally assays from $100 to $200 per ton. These veins are essentially similar to many of those worked profitably in California and Australia.

These may graduate into class 2, a series of lenticular-shaped quartz deposits, following the stratification of the enclosing rocks. These bodies follow one another at short, irregular intervals, within a certain narrow belt. They seem, so far as known, more persistent in depth than in length, and are often rich, several instances being, at this moment, and under disadvantageous circumstances, profitably mined. Class 3 are the so-called "bar"* deposits. These "bars" are now quartzites, though once presumably beds of sandstone, since altered. They are very persistent, and often traceable for miles. They are also, to a certain extent, pyritiferous. The gold in them may occur in chutes (Sheba mine), or it may be disseminated regularly for some considerable distance, though in this latter case, although chutes are not found, the gold is richer in some parts than in others. These quartzite "bars" are generally associated with diorite dykes, and are in places fissured and fractured by them. These fissures have subsequently been filled with a different variety of quartz often richly auriferous and occasionally barely distinguishable from that of the bar itself. Instead of quartz, these fissures are sometimes filled with a deposit of iron oxides. All the ferruginous deposits contain gold, and very frequently assay sufficiently well to be commercially valuable. However, their free-gold contents are generally small, and since plate amalgamation is the only method adopted here, they have in no instance been successfully exploited.

*"Bar"—any persistent, well-defined outcrop of any rocks except a quartz reef.

BARBERTON, LOOKING TOWARDS MOODIE MAIN GOLD-FIELDS.

There are other ways in which gold is found in this district. In the shaly rocks are often found similar deposits of inconsiderable width, principally made up of iron oxides, often extremely rich in gold. These are, however, of too minute dimensions to be worked profitably. They are known locally, from their color, as "burnt leaders," though of course deposited from aqueous solutions. In the quartzite beds also extremely rich "pockets" of gold, with the most irregular outlines, have been found.

On the whole the eastern Transvaal gold-fields constitute a district of vast capabilities, which will compare favorably with the Californian and Australian gold regions. The physical difficulties are considerable, but not extraordinary as compared with the other regions mentioned. The exceptional richness and unheard-of facilities of the Witwatersrand district have temporarily drawn the chief attention of the mining public away from these eastern fields, but they are indubitably so rich that on the completion of the railway system, now under construction, the by no means inconsiderable industry now in existence will again receive the impetus still necessary to its due expansion.

The history of the initiation of the mining industry in this district may be briefly stated. From the year 1875, when the Lydenburg alluvial miners were turned off their claims in favor of the handful of concessionaires among whom the Boer government had divided the district, until 1882, the development of South African mining had taken no further strides. The Sikukuni war, the annexation of the Transvaal by the British, the subsequent Boer war and reëstablishment of the Transvaal republic had kept the whole country too much disturbed to allow of any great and general industrial movement. Nevertheless the mining industries of South Africa elsewhere, the diamond mines of Kimberley and the Orange Free State, the copper of Namaqualand, and even a lead-mining venture at Marico in the Transvaal, and, to a lesser extent, the gold companies founded at Lydenburg, continued to hold their own. The more or less steady returns of these industries, the magnificence of the success of the diamond-fields more especially, sufficed to encourage a few enthusiastic prospectors to pursue their researches farther afield, and yeoman service was rendered during this period by a small handful of men in preparing the way for the next great movement in approaching quieter times. The Swaziland gold-belt was located in 1880, and concessions obtained from King Kubandine by M'Lachlan, Pigg, Forbes, Carter, Charlie

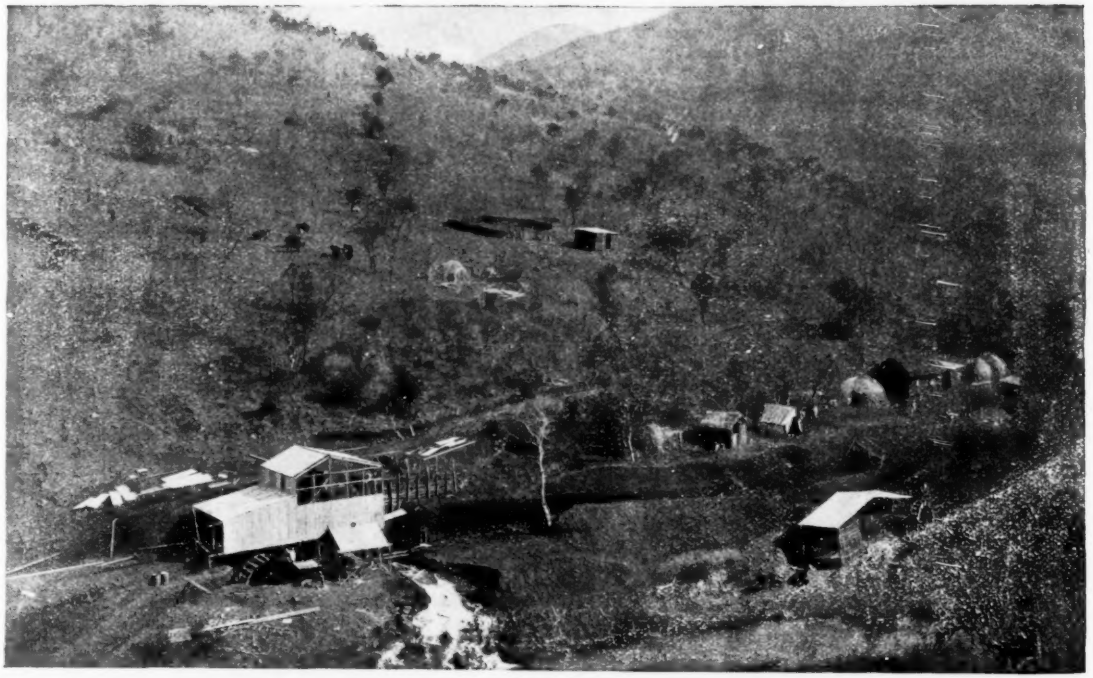
BARBERTON, WITH EAST MOODIE HILLS BEHIND.

the Reefer, and others over tracts of ground which have since attracted considerable attention under the well-known names of Forbes's concession, Pigg's peak, the Havelock, etc. About the same date the existence of payable "alluvial" at the Kantoor was established, practically by the same men; and it was during this period that the surveyor-general of the Transvaal, Mr. Moodie, secured from the Boer government for the sum of $25,000 a block of thirteen farms, or about 80,000 acres in all, lying to the south-west of the de Kaap valley, to be known later under the name of the Moodie gold-fields, as a mining area quite exceptional in the richness of its somewhat limited masses of gold-bearing veins.

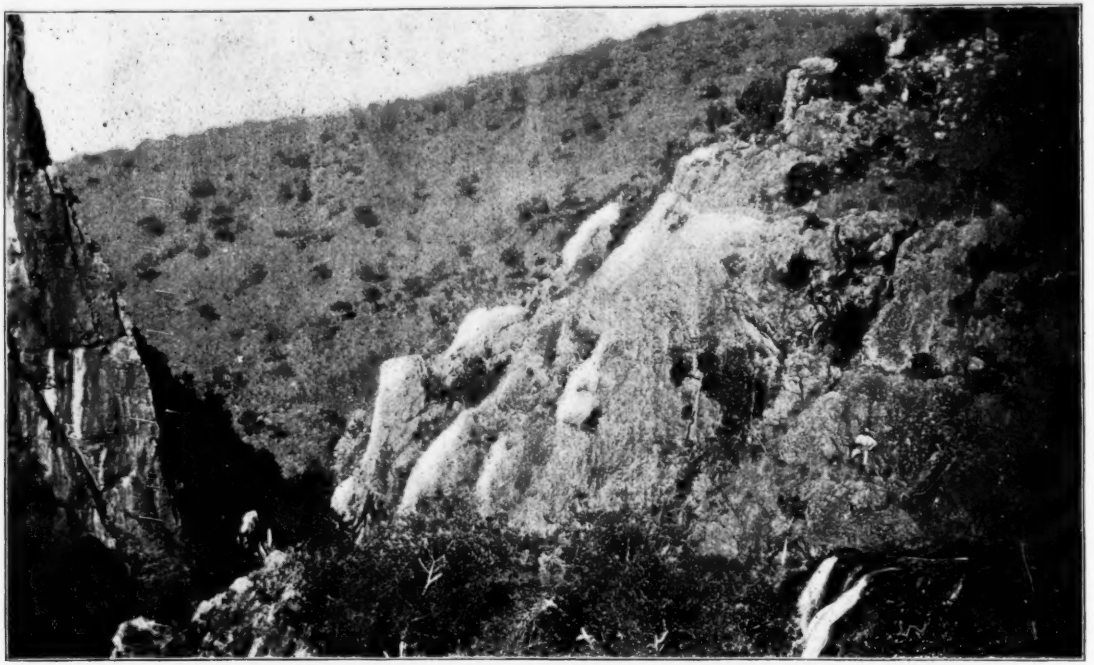
With the advent of peace in 1881 the stream of diggers again set in, in earnest, towards this eastern portion of the Transvaal. By 1882 there were probably some 2000 diggers at the Kantoor, and almost as many more at Moodie's. The history of the Kantoor "alluvial" fields has been very spasmodic and irregular. There have probably never been more than 3000 men at work there at a time from their discovery to the present day, when there may be perhaps 200. The position of the district, on the summit of the highest point of the Drakensberg, has limited the period during which it is possible to work to the four or five months of the rainy season; for the rest of the year sluicing is almost impossible.

During the period from 1882 to 1891 perhaps some 30,000 ounces worth $600,000 in all may have been won, but, as on all alluvial fields, an accurate estimate is naturally impossible. The largest nugget known to have been found, the President Kruger, weighed in gross 238 ounces and contained 110 ounces of pure gold. One man is known to have found 550 ounces in twelve months, another 225 ounces in six months, and so on. Then the lower portion of the district, Jamestown, and perhaps, for a time, the richest, had to be abandoned from unhealthiness. Another portion, Barretts-Berlyn, was allotted after the Lydenburg manner to a company and the diggers turned off. The majority of the diggers, disheartened at the lack of water, left for the more promising district of Moodie's in 1883 and 1884. Still the richness of the Kantoor fields is indisputable. For ten years it has supported, and does still support, a body of some hundreds of diggers, and a small township, out of the returns of genuine alluvial mining. Were it possible to obtain a sufficiency of water the returns of the district would be phenomenal. Barretts-Berlyn has been steadily worked to date, and is now

FONT BOAT ON KOMATI RIVER—SCENE SHOWING ROAD FROM BARBERTON TO SWAZILAND—MOODIE HILLS IN THE BACKGROUND.



PROSPECTING BATTERY ON PROPERTY IN SOUTH MOODIE'S.



SOUTH AFRICAN PROSPECTING—TESTING THE BUCK REEF, SOUTH MOODIE'S.

fairly remunerative. The Jamestown district has been the scene of various unsavory episodes in the way of company-mongering, in which Cabinet ministers from Cape Colony have been concerned.

Contemporaneously with the discovery of the Kantoor, prospecting was commenced at Moodie's, a range of hills thirty-five miles southeast of the Kantoor, and by the middle of 1882 some 300 men were engaged in alluvial mining and "reefing" over the farms Oerschot, Sassenheim and Armide. The chief gold was won by "dollying" the extraordinary number of thin but rich segregated quartz veins by which the greater part of the Moodie hills are threaded. By the end of 1883 the visible signs of richness established were alone amply sufficient to account for the rush that then took place to Moodie's, and, in the following years, to the neighboring district of Barberton. The veins, or "reefs," in African mining parlance, were then to be seen in many instances exposed, to a depth of from twelve to fifteen feet, for considerable distances, waiting to be pulled down on the arrival of machinery, and showing solid walls of quartz from which the visible gold could be picked with a penknife or the thumb nail. In other parts, nature, as a local digger's description had it, seemed to have taken equal parts of gold flour and sand and baked it to a paste. A well-known miner, "French Rob," one of the first to commence erecting the small dollies, with the ruins of which, and of the water-wheels that drove them, Moodie's is still well covered, had, by 1883, four dollies at work; he sometimes crushed 5½ ounces out of 1½ hundredweight of quartz, his average yield per hundredweight being 1½ to 2 ounces. There were certainly by 1883 two dozen dollies erected on this reef, worked either by native labor or water-wheels, crushing about 1 to 1½ tons per day each; the yield being over 1½ ounces per dolly per day. The Pioneer, Tiger Trap, Beehive, Phœnix, Robwinia, Alpine, Rosetta, Try, Woodbine, Highland, Abbotts, Golden Hill, etc., all veins traceable for considerable distances over the precipitous hillsides forming the Moodie valleys, were by 1884 cut up from end to end into claims worked by individuals or groups of miners. By the middle of this year the population of "Moodie's" formed a bustling and flourishing community of 3000 to 4000 souls, divided into the three camps of lower, middle, and upper Moodie's and their off-shoots.

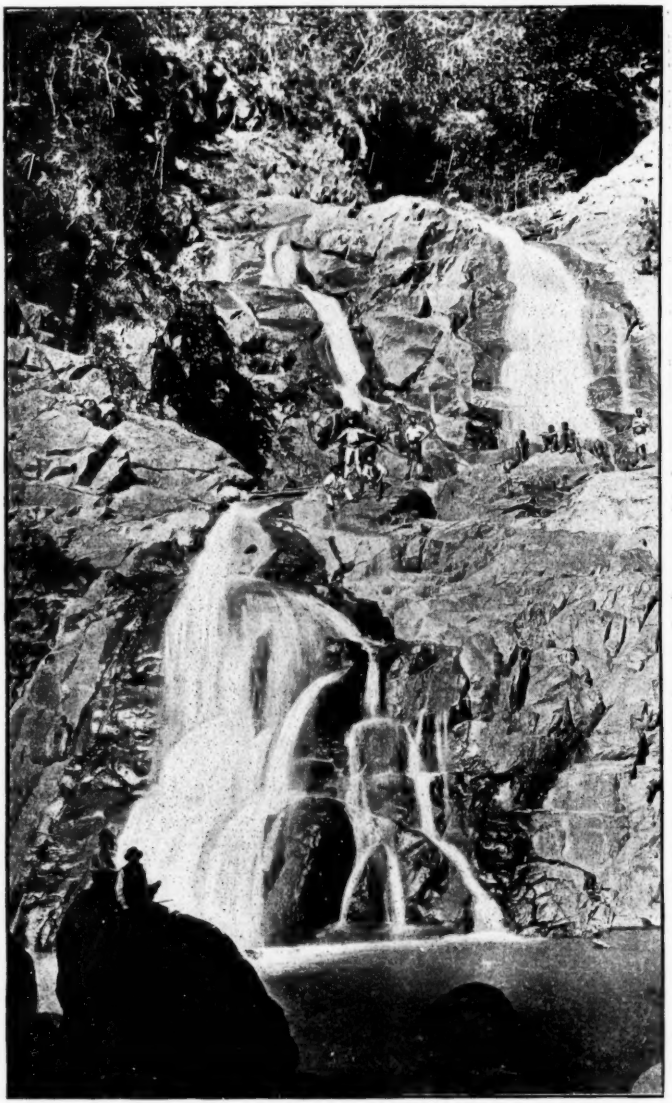
So long as it was a question of surface workings all did well. Most of these veins have been worked since by companies, and the heaviness of their returns is sufficient warrant for the amount of

SOUTH AFRICAN TYPES OF LABOR—PROSPECTING PARTY IN SOUTH MOODIE'S.

gold that must have been extracted in the earlier years by these individual diggers. Almost before the exigencies of deep mining, however, could tell upon the primitive methods then in vogue, the question of the ownership of the ground, and the right of the diggers to be there at all, brought the whole matter to an abrupt and stormy close. The original prospectors had invaded Mr. Moodie's property, then a totally uninhabited tract of the remoter Transvaal, without question as to ownership, and on demand from him, in 1883, of payment of a royalty of all gold won, had offered a far smaller percentage than Mr. Moodie felt disposed to be contented with. The validity of his title had from the commencement been disputed, on grounds long since abandoned. He had, with perhaps more reason, been accused of luring prospectors on to his ground by a published announcement of its supposed richness, in 1882, and of having, in 1884, owing to the exaggerated rumors of the finds, raised his terms to an extent afterwards confessed to have been excessive. The average yield of the reefs found by them was confidently expected at the time to exceed sixteen ounces.

In any case, a digger's committee had been formed to maintain order and superintend interests, and one of their summary methods of jurisdiction, "chucking off the mill," had been freely held out in prospect to Mr. Moodie or his agents, as the probable result of interference. Mr. Moodie in 1884 solved the difficulty by disposing of the whole of his property to a Natal company, the original Moodie's Gold-Mining Company. This company, partly by an appeal for government aid, culminating in the appearance of the Transvaal artillery on the scene, and a display of considerable unwillingness on either side to come to an actual conflict, and partly by judicious concessions, succeeded in establishing their rights and in inducing the more successful diggers to remain under new conditions and terms. By the end of 1885 most of the proved reefs had been floated into subsidiary companies, and though the excitement in 1886 over the larger and richer finds at Barberton, and the still more substantial and important discoveries in 1887 at Witwatersrand drew the attention of the mining public largely away from Moodie's, it has been and still is a flourishing and producing area, if of comparatively minor importance. The exaggerated opinions held as to its richness in 1884 may be inferred from the fact that the Pioneer company formed that year by Mr. Percy Whitehead agreed to pay the Moodie company 50 per cent. of all gold found. This, however, was reduced later to 8½ per cent.,

UNITED PIONEER GOLD-MINING COMPANY'S PROPERTY, UPPER MOODIE'S.



WATER POWER FOR ELECTRICAL MACHINERY, FORBES'S REEF, SOUTH AFRICAN GOLD-FIELDS—LOCATING PIPE-WAY.

of which the Moodie company paid 2½ per cent. to the Government.

A better gage of the value of the district is given in the returns. In 1885, according to Mr. Mather, 4467 tons were crushed, yielding 6478 oz., 17 dwt., 21 gr.; from January 1886 to April 1887, the 7872 tons crushed yielded 11,386 oz., 6 dwt., 6 gr., an average for the period mentioned of 29 dwt. per ton. A total of $40,000 worth of alluvial is estimated to have been found within this period. Some of the "reefs" have been exceptionally rich. The Alpine maintained an average of 13 ounces to the ton from a small lead for months. The Try, Pioneer, Whiteheads and others averaged for some time considerably over 2 ounces per ton; and the Union, after a protracted pinch, bringing their £1 shares to under 1s. 6d., struck a pocket of such richness that their scrip rose to over £18 in less than a fortnight, and so on. By this time, the end of 1885, public attention to the practical possibility of the existence of payable gold-fields in South Africa was fairly awakened; and the announcement early in the following year, of discoveries in the hills behind Barberton that should place the question beyond all doubt, found a community fully prepared to invest the capital and energy required for the due examination of the district.

THE FACTS ABOUT RAIN-MAKING.

By George E. Curtis,

Meteorologist to the Recent Government Rain-making Expedition.

THE recent experiments by the Government to produce rain by explosions have received a degree of popular attention seldom accorded to Government scientific undertakings. Throughout the southwestern portion of the country, where rain is the one thing needful, the operations excited a profound interest and awakened lively anticipations of success; and when it was announced that rain had been produced, the news was received with very general acceptance over the entire country. Since the return of the expedition this widespread interest not only has not abated, but in some western States has been increased by the formation of artificial-rain companies which are contracting with communities to do the public watering at a stated price per acre. These indirect results now give the matter a new importance and make its discussion worthy the attention of both those who have advocated and those who have ridiculed the undertaking. It is not merely to refute a theory, but to correct a prevailing misconception as to fact, that a specific account should be given of the experiments that were made and of the rainfall that occurred, accompanied by a critical judgment of their relation to each other based on all the available data. I purpose, therefore, to present the essential facts concerning the operations and their results, taken from my notebook, as meteorologist of the expedition, and with a text gained therefrom I desire to call attention to some of the broader aspects of the subject which as yet have scarcely been recognized.

The experiments, though made under the direction of the Secretary of Agriculture, were not undertaken on his responsibility nor on his recommendation, but in accordance with the provisions of an appropriation originating in Congress itself. As no bureau of the Department of Agriculture was equipped for investigations of this character, a special agent was appointed to expend the appropriation and several months were spent in deciding on methods of experiment and in providing apparatus. The explosion of oxy-hydrogen balloons in the air at different elevations was adopted as

one of the chief methods to be employed. Preparations were also made to fire sticks of dynamite carried up in the air by kites and to explode rackarock (an explosive consisting of three parts of potassium chlorate to one part of nitro-benzol) and dynamite on the ground. With materials for carrying out these three lines of experiments, the party went early in August, 1891, to the "C" ranch of Mr. Nelson Morris, twenty-three miles northwest of Midland, Texas (latitude 32° 14′ and longitude 102° 12′). Every facility which the ranch afforded was offered by the hospitable and obliging manager, Mr. Edward Rannels, but the distance from any source of supplies proved a serious obstacle to the satisfactory conduct of the operations.

The preceding month had been one of more than usual dryness throughout western Texas, but in the southwestern part of the State the drought had been broken by a heavy storm on August 1, which came as a welcome and prompt announcement of the advent of the usual August rains.* The first rain after the party reached Midland began shortly after noon on August 10, and continued at intervals until evening. Although the statement has been published† that "nearly two inches" of rain fell, it must be said that an actual measurement was not made, and that this amount is simply an estimate by one not accustomed to quantitative measurements of rainfall. During the latter part of the afternoon the present writer, while *en route* to Midland, met a sharp shower at a point near Sweetwater, 100 miles east of Midland. Light showers or sprinkles continued at intervals until sunset, at which time there were indications of heavier rain to the north. I mention these observations as evidence that a general showery condition prevailed that afternoon over a very considerable area.

The rain-making party happened to do their first firing on the preceding evening, August 9. This consisted of a few shots of rackarock exploded as as a test of material, but with no idea of considering it as an experiment to produce rain, and of course no result was anticipated. As I was not then present at the ranch I have no record of the amount of firing done, but Mr. Powers, the

---

* The newspapers published the following Associated Press report on August 3: "THE TEXAS DROUGHT BROKEN.—SAN ANTONIO, TEX., Aug. 2.—The terrible drought prevailing in the southwest of Texas for nine weeks was broken last night by a storm followed by drenching rain. Only two showers had fallen for nine weeks in the vast area south of San Antonio for 200 miles and west for 400 miles. Cotton-bolls had begun to drop from the stems, the corn crop was ruined, and the cattle ranges had been parched."

† *North American Review*, October, 1891.

author of "War and the Weather," states that *only two* shots were fired, and Mr. Myers the balloonist estimates from memory that there were perhaps three shots.

Immediately after reaching the "C" ranch I began systematic meteorological observations with a Robinson anemometer, two psychrometers, rain-gages, an aneroid barometer and a Richard barograph. The last-named instrument is a very delicate self-registering aneroid barometer, which makes a continuous registration of the changes in atmospheric pressure upon a cylinder revolved by clockwork. In addition to the automatic registration of the varying atmospheric pressure, the instrument recorded the magnitude of the instantaneous air-waves produced by the explosions. All records were made on Central time.

On August 12, after a calm afternoon, the wind blew up strong from the southeast at 5.45, and three-quarters of the sky became covered with clouds. A number of dynamite sticks were exploded a few rods from the house, producing an oscillation of about 0.05 inch in the trace of the barograph. This means that the air-wave set in motion by the explosion produced a condensation and rarefaction in the air equivalent to about $\frac{1}{600}$ of the total atmospheric pressure.

August 13, 14, and 15 were dry, clear days, excepting the afternoon of the 15th, when the sky was partly covered with patches of cumulus cloud. Dynamite sticks were again fired on the 14th and 15th on a small scale but no rain followed and no telegraphic report of these operations was sent. They would not, in fact, be of sufficient importance to mention, were it not that equal care is taken in recording similar "experiments" on other days, when slight showers passed over the ranch.

The clear weather was interrupted on August 16 by a period of cloudy, showery weather which continued through the 18th and recurred on the 20th. The wind having blown for several days from the southeast, cumulus clouds began to gather earlier and in greater amount than on the preceding days, and by 1 o'clock largely covered the sky. The week preceding August 16 had been spent in efforts to get the generators in operation for filling the balloons, and after many causes of delay a balloon was now in process of inflation. The cloudiness continued to increase and since it was not possible to expedite the filling of the balloon, an assistant began to prepare for ground explosions of rackarock powder in order to experiment under these conditions. At 3.15 P. M. a seven-minute

shower fell from the thin cumulus clouds but the amount of rainfall was inappreciable. During the afternoon about fifty pounds of powder were fired in a number of small blasts, without any recognizable result. The rackarock was generally fired at a distance of a half-mile from the house, and the air-wave produced was not sufficient to affect the barograph at that distance. The cloudiness continued through the afternoon and at 7 P. M. covered 80 per cent. of the sky. At 6 P. M. the filling of one balloon was completed, and it was set free with a lighted time-fuse attached. The balloon was carried by successive currents until apparently over a mile distant and fully a half-mile high when it exploded. The distance was so great that the barograph was unaffected and the sound of the explosion was somewhat faint. The explosion of the balloon was not accompanied or followed by any rainfall. In the evening lightning was seen in a small cloud-bank in the southwest, from which rain was falling, but the shower did not reach the ranch.

On the 17th the weather continued cloudy and unsettled. The clouds began to gather before noon and the wind blew strong from the east-southeast. From 3.30 to 4.30 heavy storm-clouds and lightning were seen in the west and southwest, and several slight sprinkles occurred from dark cumulus clouds overhead, this being *before any explosions had been made.* The main body of the storm was entirely to the west of the ranch and continued visible for some time in the northwest, thick and dense on the horizon. At 5.10 the first explosions of the day were begun; three blasts of rackarock were fired, but the storm had passed and no more rain followed at the time. At 7 o'clock another storm appeared in the southeast, and in the course of an hour light showers reached the ranch, while the explosions of rackarock and dynamite were renewed. The total rainfall, however, was inappreciable.

What, now, we may inquire, was the relation of the showers to the explosions? Those that came before the explosions, manifestly, were not caused by them; those that came after the explosions were very like the preceding, and, in fact, were in sight before the firing began.

August 18 opened with the sky almost entirely covered with stratus cloud. The sun shone out at 8.40, but soon was obscured again by general cloudiness. Judge Ethan Allen, of Marienfeld, a visitor at the ranch, predicted that there would be rain before night. Before noon the prediction was verified, for slight sprinkles were felt several times between 10 and 12 o'clock. At 2 P. M.

a storm was observed in the southeast and at 3.30 thunder was heard in the east, accompanied by a strong wind. An assistant then went out to fire rackarock and the explosions, which began about 4 o'clock, continued at intervals through the remainder of the day. In all eighty-four pounds of powder were expended in fifteen blasts. At 4 P. M. the wind was blowing twenty miles per hour from the east and the storm which had gathered in the southeast spread over the sky. At 4.50 light rain began to fall and continued until 5.30, giving the first measurable rainfall of 0.02 inch. At 7 P. M. clouds were seen in the east, but no more rain fell. The following day was clear and no explosions were made.

On August 20 the sky became overcast in the afternoon, and at 4.15 storm-clouds extended from the northern and northwest horizon to the zenith. The southern half of the sky was clear, but thunder was heard in the north. At 4.22 the wind shifted to the north and blew with a velocity of twenty-five miles an hour. An assistant then started out to fire rackarock, no explosions having been made since the 18th. The storm-clouds blew rapidly overhead from northwest to southeast, and at 4.58 drops of rain began to fall—four minutes *before* the first explosion of rackarock. Two blasts followed at 5.08 and 5.15. At 5.25 quite a little sprinkle of rain fell, but it soon ceased. At 5.38 a fourth blast was fired, but the greater part of the storm had passed over and descended again to the southwest, where lightning was seen at 5.55. Thick clouds, however, continued overhead. At 6.15 a kite was sent up carrying two sticks of dynamite ; just before the dynamite was touched off drops of rain were felt, but no perceptible increase followed this explosion and shortly afterwards the sprinkle ceased. At 6.30 the wind blew in strong gusts from the southwest and storm-clouds extended from that quarter to the zenith. At 7 o'clock another explosion was made and was followed by drops ; ten minutes later there was increased sprinkling. But the total rainfall did not lay the dust or become measurable by the rain-gage.

The 21st was a clear day and extremely hot, the maximum shade temperature being about 97°.5. In the evening 156 pounds of rackarock were fired in fourteen blasts. During the night the wind changed to the north, the barometer began to rise rapidly and the temperature fell with equal suddenness and rapidity. Although it was August, a genuine Texas norther was upon us. In the morning, August 22, the sky was overcast with an unbroken layer of cloud, the wind blew in gusts from northeast and north-north-

east, and it was so cold that a fire was built for comfort. At 7.40 a fine mist began and continued for several hours. The rackarock firing was again resumed at 8.25 A. M., with a disposition of 276 pounds of rackarock in seventeen blasts. However, all this firing was without apparent effect, as not the slightest result was observable, and at 2 P. M. the sky was clearing. The mist had been so light that no rainfall was found in the gage.

The weather-maps for August 20 to 22 show the progress of this norther as it advanced toward Texas, and also the rains which marked its advent. At Abilene the rainfall was 0.70 and at Roby 1.00 inch. The study of the daily weather-charts shows that these rains were essentially due to the norther and may be ascribed to the uplifting of the warm moist air by the cold, dry north wind. Where the air was more humid a considerable rainfall occurred, but at the "C" ranch there was only a fine mist. On August 24 the pressure fell rapidly and by 2 o'clock was below the normal, while the wind blew again from the southwest with a velocity indicating the approach of another cyclone. The meteorological observations close on this date on account of the return of the meteorologist to Washington.

Strenuous efforts were made to fill and explode balloons on the 23d and 24th, but it was not until the 25th that the difficulties were in a measure overcome, and after several failures two balloons were actually exploded—one at 10.45 A. M. and the second at 2.45 P. M. As a final effort, the evening was spent in firing the remainder of the stock of explosives. Eighteen blasts or shots were fired from 8 to 11 o'clock. Before daylight thunder was heard followed by a *sprinkle* of rain. At the ranch there was nothing but a *sprinkle*, though to the northwest there seemed to be a heavy shower. In the morning the firing was resumed, but it did not produce more rain and the experiments were ended.

This accurate account of the operations of the 25th and of the ensuing thunder-storm has been kindly furnished me by Mr. Edward Powers, who was present at the ranch throughout the experiments. In commenting upon this last storm Mr. Powers says: "The indications were that this rain was an artificial one and I believe it was the only artificial one produced. But it was nothing but a sprinkle; my only wonder is that any rain whatever was produced by the insignificant amount of firing done."

In the absence of any visible indications of rain on the 25th it was natural to attribute this thunder-storm to the explosions, and

if there were no other counter evidence, this case might stand as a single instance in which the experiments were successful in developing a storm. But even this case is rendered valueless as evidence by the meteorological records made at neighboring stations of the Weather Bureau and especially by the weather-map for 8 P. M. (Eastern time) of August 25. The approach of an area of low barometer indicated on the 24th by the barograph at Midland is exhibited in the barometric records at Abilene and El Paso. These records show the prevalence of low pressure beginning on the 24th and extending through the 25th, followed by a materially higher pressure at 8 A. M. of the 26th. The low pressure passed away during the night of the 25th and the barometric change was coincident with the thunder-storm at Midland. These conditions are presented on the weather-map for 8 P. M. of the 25th, on which an extended low area is seen over the extreme southwest; rainfall is reported from Fort Stanton, New Mexico, and variable winds show an unsettled condition of the atmosphere favorable to showers. These conditions were recognized by the forecast officer, who made the prediction: "For eastern Texas, generally fair, except *local showers* on the extreme southeast coast *and the northwest.*"

Thus we see that the probability of rain in northwestern Texas was so great that showers were predicted by the officer in Washington. Under these circumstances the thunder-storm which touched the "C" ranch no longer appears to be a result of the explosions, but is the normal and usual accompaniment of the barometric conditions which prevailed. Moreover attention should be directed to the fact that the center and great body of the storm was to the northwest of the ranch and that apparently only the edge of the storm was experienced. The only instance, therefore, in which it appeared to a candid observer that the explosions had produced a storm proves to be one for which showers were actually predicted.

The different parts of this detailed account may now be gathered into the following summary:

1. A smart shower on the afternoon of August 10 was preceded on the evening of August 9 by two shots of rackarock to test the powder.

2. Shots were fired on August 12, 14 and 15 without effect.

3. Cumulus clouds and slight showers on August 16, 17, 18 and 20 were accompanied by explosions of rackarock and dynamite, executed when the storm-clouds were in sight, sometimes before

and sometimes after sprinkling had begun. Only on the 18th was the rainfall measurable, when it was 0.02 inch. In several cases a shot fired when a dense cloud was in the zenith seemed to produce a spatter of rain. On three of these days *sprinkling occurred before any firing had been done.*

4. On August 22 a fine mist due to a severe norther was preceded on the 21st by the explosion of 156 pounds of rackarock. During the mist 276 pounds were fired without effect.

5. Early on the 26th, when local showers had been predicted for this region by the Weather Bureau, and when the continuous barometric records show the passage of an area of very low pressure, the border of a thunder-storm touched the "C" ranch and gave a sprinkling of rain. Final explosions had been made on the preceding evening, and in the report of the expedition published by the Department of Agriculture they are denominated "the Midland test." This case, therefore, is presented as the principal, if not the only, operation at Midland from which the efficacy of explosions in producing rain may be judged. But it fails to afford the primary condition of a crucial test, for at the same time that the experiments were made, the natural conditions antecedent to and productive of a thunder-storm prevailed.

Attention should also be directed to the fact that the total rainfall for these eighteen days is less than that measured at many surrounding stations of the Texas Weather Bureau, as shown in a table kindly furnished me by Mr. I. M. Cline, assistant director of the State Weather Service. This table shows that the total rainfall for August in northwest Texas ranged from 0.35 to 2.31 inches and that between August 9 and 26 there were nine days when measurable rain fell at one or more stations, while at the "C" ranch there were only two days of measurable rainfall. All the data from the "C" ranch and from the other stations confirm and illustrate an important climatic feature—namely, that August is the beginning of the rainy season in northwest Texas. The occurrence of these showers at the "C" ranch and at the stations of the Texas Weather Service was not due to the presence of the party of experimenters, but to the advent of the rainy season.

Examined in detail with all the circumstances both of the operations and of the weather recorded, it is evident that the experiments have utterly failed to demonstrate that explosions can develop a storm or can produce a measurable rain, and they have been not only unsuccessful in result, but meager and trivial in them-

selves. After the conclusion of the experiments above described, two members of the party continued operations at El Paso and at a point near San Diego, Texas. It is stated that at these places the explosions were on a much more extensive scale than at Midland. A careful study of the report of these operations and the attendant weather fails, however, to assure me that the results were any more conclusive.

Although for all practical purposes the experiments at Midland were a failure, we may recognize a single result of scientific interest that seemed to be fairly well attested. In several instances, when a dense threatening cloud was overhead, a sharp detonating explosion was followed after an interval of twenty or thirty seconds by a spatter of rain, or if it was already sprinkling, the blast was followed by a very noticeable momentary increase of the drops. This result occurred a sufficient number of times to indicate that the phenomenon was a real effect of the explosions. The importance of the observation lies in its bearing on the cause of the similar phenomena frequently noticed during thunder-storms, when a clap of thunder is followed by a shower of large drops of rain. Whether these drops are aggregated mechanically by the air-waves set in motion by the concussion, or whether on the other hand, it is a rapid condensation that produces at the same time both the large rain-drops and the electric charge, has been much discussed, but the weight of opinion is in favor of the latter view.

This interesting result (if such it prove to be, for it is not yet conclusively established) is not, however, what the experiments were designed to accomplish, which was to produce rain in measurable quantity and whenever needed, so as essentially to transform the conditions of habitation of the semi-arid plains and thus largely to increase the value of these lands. The appropriation has been expended, but the hoped-for modification of climate is no nearer realization than before, and no indication has been obtained that there is any possibility of accomplishing it. But the mere waste of nine thousand dollars would be of small consequence if the effect of the enterprise could be confined to the coffers of the Treasury. A very serious phase of the matter is the secondary effect of the experiments on the public mind and the resulting attitude of the people towards fruitful meteorological investigation.

In the first place, the simple fact of the conduct of such experiments by the Government invests the attempt with an importance which it could not otherwise obtain. A private individual may

engage in some impracticable scheme, without seeking the counsel or even against the advice of competent specialists, and no attention will be paid to it. But if the Government engage in the same undertaking it is immediately assumed to be a rational project. This is necessarily the case, for the public at large have no means of distinguishing one project from another. Thus, in the present instance, people in general had little knowledge that the appropriation was made by Congress principally at the instance of a single member, without the recommendation or endorsement of the scientific staff of the Department of Agriculture or of any reputable physicist in the United States. Accordingly, the undertaking was assumed by the great body of the people to be one of the lines of investigation taken up by the Department of Agriculture, and so the responsibility for it was thrown alike upon the Government and upon science. The efforts of the Government are accredited because they are believed to be the outcome of the best scientific thought of the day.

This confidence of the people in the scientific work of the Government is a gratifying tribute to the labors of our scientists and an unconscious testimonial of which they have reason to be proud. But the greater the confidence which is reposed, the greater is the responsibility not to abuse it. Both wisdom and economy suggest that Congress should hear the opinions of competent specialists before engaging in doubtful scientific projects. Likewise, there rests upon every scientist in official position the responsibility of not advising any investigation which will not bear the closest scrutiny.

While traveling through the Southwest last summer my first observation and my last was the profound interest felt by all the people of that region in the outcome of the rain-making experiments. A feeling of expectancy pervaded the entire region from St. Louis to El Paso—a readiness to believe in the possibility of accomplishing almost any result that the expedition might attempt, however chimerical or impracticable it might at other times have seemed. This was not credulity, it was faith—faith in the Government, faith in science, and faith in the honesty and sincerity of the Government's agents. I then began to see how seriously the confidence of the people had been abused even in the organization of an expedition to make rain by concussions, for meteorologists have declared unanimously that the idea is not supported either by rational theory or observational data. Viewed historically, the idea that noises and concussions will produce rain is found to be a part

of the folk-lore of very many primitive peoples, and to revive it now is to reject the light of civilization and to retrograde to a cruder and less rational apprehension of natural phenomena.

Nor was the impression thus awakened either corrected or compensated by the subsequent methods employed. The effect of the undertaking became widespread and irreparable through the sensational accounts which were telegraphed to the press and published in every village in the land. When I arrived at Midland on August 10 I found there an employé of the expedition, who had come in from the ranch where the experiments were conducted, to send a first telegraphic announcement to the country. The occurrences upon which this telegram was based have already been described. On the preceding evening, August 9, two or three shots of rackarock had been fired, not as an experiment to produce rain, but simply as a test of material, and no result was expected; but the next afternoon, when considerable rain fell, the *post hoc* and the *propter hoc* were identified and the following message was hurriedly sent :

" *The Hon. C. B. Farwell, Chicago:* Preliminary. Fired some explosives yesterday afternoon. Raining hard to-day."

The first telegraphic report was followed at intervals by others which were sent throughout the country and were cabled abroad. As the actual operations and results have become known, the attitude of the newspapers very generally has changed from unsuspecting and ready acceptance to satire and ridicule. But the widespread belief in the first announcements of success cannot easily be corrected. Where millions saw the dispatches, only hundreds have read a detailed account of the exact facts, and a vast number of the people still believe that the experiments were in some degree successful, and that noises and concussions, when made for the purpose, will produce rain. So error which will require years of teaching to eradicate has been sown broadcast in a single summer, and the rain-making myth is added to the numerous errors about the weather which already prevail.

Charlatans and sharpers have not been slow to seize the opportunity thus afforded. Artificial-rain companies have sprung up and are now busily engaged in defrauding the farmers of the semi-arid States by contracting to produce rain and by selling " rights " to use their various methods. In South Dakota public meetings in their interest have been held and the subject has become one of the vital questions of the day.

Those who have read the later detailed accounts of the operations, as well as the telegraphic despatches, have in general suspended judgment upon the question. In the midst of conflicting statements they do not know what to believe, and the only thing clearly apprehended is that their confidence was misplaced. This may prove to be a blow to scientific meteorology even more serious than the dissemination of error. Of all the sciences the results obtained by meteorology, contain least that is dramatic or spectacular. It is built up of generalizations and inductions based upon years of faithful prosaic observation, and this must continue to be its province. But these experiments have easily captivated the popular mind and aroused a cry for their continuation, in consequence of which it will be more difficult than ever to interest the people in the very commonplace methods of meteorological investigation.

This aftermath of the rain-making experiments, although unforeseen, serves as an excellent warning. For the honor and good name of the Government and of science, it would be well if we had seen the last appropriation to produce rain by bombarding the heavens, and the last expedition which should mislead the people by sending out premature and sensational reports.

PRACTICAL HINTS ON HOUSE-HEATING.

By Leicester Allen, A. B., M. E.

II.—THE ARCHITECT CONSIDERED.

HEATING engineers will agree with me that much of the difficulty experienced in properly heating and ventilating buildings is the result of architects' sins of omission or commission. The word "commission" is not intended to be interpreted in the commercial sense, though there are a few cases, I grieve to say, in which such an interpretation would be not only allowable, but pertinent. In a profession the integrity of which is, in general, *sans reproche*, it is to be lamented that any one of its members should be willing to stoop to the practice of favoring dealers and contractors who secretly pay for such favor by commissions, or *presents*, as they are called sometimes. As such men are justly held in contempt of honest people, I have nothing to say to them. It is the typical architect who represents the great body of his profession and whose honor is above suspicion whose ear I now seek.

Time was when the designing of a building, let us say a mansion, was a very much simpler task than it is at present. The large open fireplaces used for warming buildings introduced no artistic difficulties; on the contrary they lent themselves very readily to the requirements of artistic design. These ancient fireplaces and mantels were in fact so capable of ornamental treatment that although their functional value, in the march of improvement, has passed away, they are still introduced and retained as features of interior design by the best modern architects. It is true that one of their functions, that of ventilation, is yet made available by the use of grate-fires, gas-logs, or miniature wood-fires that but feebly recall the grand wood-fires of former generations, but which serve to maintain an outward flow of air through their flues. For the most part, however, in modern houses, the whole affair is a pleasant fiction of utility, its sole purpose being for ornament.

When stoves began to supplant the old-fashioned fireplace, the architect's work was not much affected. The stove became an article of furniture and did not need any special consideration in the design. The sham fireplace could be treated for artistic effect just as well as the real one. But by the time the stoves began to make way for warm-air furnaces, and these, in their turn, began to be crowded out by steam-heating appliances, the architect found a new element materially influencing design. The warm-air furnaces demanded room and place for flues through which air could find entrance and exit, and for the registers that control the flow. The flues could be concealed in walls and partitions, but they

took up room and compelled positions often unfavorable to the introduction of architectural features which designers were reluctant to abandon. Finally, the advent of steam-heating and hot-water heating introduced an entire new set of problems. These problems require for their proper solution an acquaintance with the properties of steam and its circulation through pipes, and of the flow through pipes of water put into motion by heat. They included the construction of steam-boilers and of hot-water heaters, and calculation of their sizes relatively to a required quantity of heat to be generated in their furnaces and to be conveyed to different parts of a building. Among them was the always-recurring question of how much direct or indirect heating surface is required to heat different apartments, differently situated, differently constructed, inclosed by different materials—as brick, wood, glass, iron or combinations of these—and requiring to be kept at different specific temperatures. The computation of sizes of pipes necessary to convey the requisite amount of steam to heaters, and their proper positions, with all the details of construction of an effective steam-heating or hot-water heating apparatus, must be added to this enumeration. Lastly, the problems of effective ventilation, varying constantly, to be considered in connection with the new systems of heating, and in relation to each individual building in which improved ventilation is sought, pressed for solution. Surely and swiftly the limitations within which architects have always been obliged to work were increased by the requirements of modern living. Nor are we yet at the end. Gas and electricity as heating agents for buildings are yet to have their day, and their introduction will introduce other problems.

"The modern architect needs to know everything," once said one of the oldest and most eminent of American architects to the writer; "and," he added, "since that is impossible, and architecture now means engineering as much or perhaps more than art, architects will be compelled ultimately to divide their work with engineers, the architect's office of the future being a kind of bureau, in which a department of design will be connected with distinct departments of engineering, where the construction of elevators, heating and ventilation, electric-lighting, etc., will be considered by expert specialists in these arts."

At present many architects proceed with their designs with very little regard to heating and ventilation. Instead of consulting an expert in the early stage of the design, they either rely upon their own knowledge, or say to themselves that the heating engineer must look out for himself later on. In some cases the knowledge of the requirements for good heating and ventilation is sufficient to enable them to avoid the introduction of stumbling-blocks. But this is by no means the rule. Consider now, I pray you, some of the difficulties the heating engineer has to encounter which are results of want of consideration and forethought on the part of architects. In this part of the subject I shall draw chiefly upon my own experience.

I once was asked to draw plans and estimates for a new residence, located at a popular watering-place. The design of this building was very pleasing and the exterior effects highly artistic. A brief scrutiny of the plans, however, disclosed that not the slightest attention had been given to the requirements for heating, although it had been understood from the outset that the building was to be heated by steam. At the time the plans were submitted to me the building was erected and the roof had been put on; and all this time no concern had been felt, or doubt entertained, that a good steam-heating job could be put in without any modification of the plans. Now, to begin with, the cellar (if it could be so-called) under the building was only five feet deep; and it was found, on inquiry, that greater depth could not be allowed without danger of water backing into the cellar at high-tide. The outcome of this was that a boiler-pit had to be excavated and made water-tight, thus adding unexpectedly to the cost of erecting the apparatus.

The house was, as is often the case, surrounded with a wide veranda. At one of the angles was a room built out over the veranda having all four sides exposed, except that a part of one side lapped over the main body of the building sufficiently to allow communication by means of a doorway from the interior of the second story of the main part. Of course the excavation for the cellar did not extend under the veranda. No flue for indirect heating had been provided, and in fact it would hardly have been possible to arrange for one without a change in the plans. The designer of this building and the owner were much surprised when I announced that without some alterations it would be impossible to heat that room. Now the idea had been that the room in question should afford a sea-view from each of its sides; and as the building stood on a tongue of land projecting a mile and a half out from the main land this was a pretty conception. The view from either of the sides was especially fine, and the opening of windows permitted a very grateful circulation of sea air in hot weather. Room could have been made for either a hot-air flue or steam-pipes by lapping one side a little farther over the main part than necessary for the door. As it was, a trench had to be excavated under the already built veranda, and a riser-pipe run up through a post constructed hollow for the purpose, and the room was heated imperfectly by a direct radiator. Notwithstanding the riser-pipe connection and the riser were covered thickly with felt, the cold winds of winter sweeping under that veranda rendered the pipes liable to freeze up, an accident which actually happened the second winter after the plant was put in. All of this trouble might have been avoided by a consultation with a competent steam-heating expert at an early stage of the design.

The heating and ventilation of a mission chapel with a school-room and living-rooms for the janitor in the basement, and a parsonage, chapel and library above, once afforded me a striking example of the neglect of many architects to consider properly the requisites for steam

or hot-water heating. The plans were submitted to me and as there was no cellar whatever below the basement, the only course left was to run the steam-mains along under the ceiling of the school-room. The arrangement of the doors prevented this on two sides of the school-room, and in order to reach the school-room the steam-mains and returns had to be carried through the living-rooms in the basement. When these things were pointed out to the architect, great was his surprise and chagrin. It took some time and much explanation to convince him that the impossible was not possible. Finally he requested that I should suggest a way out of the difficulty.

Whereupon the excavation of a cellar of a size sufficient to accommodate the boiler and of trenches in which to place the mains and return-pipes was suggested. It immediately became evident that the cost of this excavation, involving considerable blasting, was a very unwelcome addition to the cost of the building as previously estimated, but as the building had not yet been commenced and the unsightly pipes were more objectionable, the boiler-room below and the trenches for the pipes were conceded. Accordingly I proceeded to draw my plans and put in an estimate for the work, which was accepted. The contractor for whom the estimate was made was, in due course, notified to proceed with the work. Arriving with his materials, he found that neither the excavation for the boiler-room nor the trenches for the pipes had been made. A requisition for this work was made upon the owner who under the contract was to furnish the boiler-room and trenches. In response men were sent to do the required digging and blasting, and it was soon found that in locating the boiler-room the architect had again overlooked an important point. The building was now up, and the excavation could not be made, as specified, without serious danger to the foundations of a heavy building adjoining as well as to the work already performed.

When this discovery was made, the owners and the architect had a debate acrid on one side and humiliating on the other; and it finally resulted that the excavated boiler-room was abandoned, the boiler was placed on a level with the school-room floor; the steam-pipes were run overhead through the living-rooms and the school-room, the direct radiators in the school-room were placed on high supports to afford drainage, and the returns were carried back along over the floors to the boiler. The whole job worked well enough in warming the building, but as an example of hideousness in appearance it stands unparalleled in my experience. Now all this bother to architect, owner, heating engineer and contractors resulted from the lack of a little advice from a heating expert when the building was first planned.

These are samples of what is constantly met with in the experience of heating experts and contractors. I could, were it worth while, multiply them greatly from my own experiences, but I have sufficiently emphasized the point made in the first paragraph of this article.

Do not, as often is practised, make a small cellar for heating appar-

atus under the front end of a large building and place chimneys (often of too small size even if properly located) at the rear of the building. It was so planned to heat a large church in a New Jersey town which I was once called upon to inspect, with a view to improvement in a heating-apparatus, necessarily a failure, from the fact that the smoke-pipes had to extend from the furnaces almost horizontally (as there was not head-room to give them much inclination) nearly eighty feet to chimneys of a size reduced to the last limit of practicability even had they been in reasonable proximity to the furnaces.

Don't expect to secure a good circulation of air in large ventilating shafts through which the smoke-pipe is carried up, relying upon the radiated heat from this pipe and the contact of air with the smoke-pipe to move the air through the shaft. Notwithstanding the numerous total failures and the still more numerous partial failures that have attended this method, it is still introduced in designs for large buildings. I am free to say that I have never seen a ventilating-shaft that worked up to half its anticipated capacity by reason of the effect of a smoke-pipe passed through it. You cannot eat your cake and have it too. In a properly-designed heating plant the smoke should enter the smoke-pipe at no higher temperature than is needful to maintain the required draft in the furnace. If any heat be subtracted from the smoke to heat air surrounding the smoke-pipe, it necessarily follows that the draft in the furnace will be diminished. If the smoke be heated unduly, that is to say, to a temperature higher than is needed to maintain a good furnace draft, there will be a serious waste of heat, and consequently, undue consumption of fuel. If circulation in a ventilating-shaft is to be produced by heat in the shaft, the heat for this purpose should be supplied from an ample steam- or hot-water pipe-coil at the bottom of the shaft. This will cost generally very much more than it would cost to get the same circulation by means of a blower, and I have come to the belief that effective ventilation at a reasonable cost, for large buildings, can be obtained only by mechanical means.

Gas-burners in ventilating-shafts, except in small shafts for ventilating water-closets, etc., are a delusion and a snare, and even for the latter purpose a steam-pipe or hot-water pipe is far better. The defects of the system of ventilation by gas-burners in shafts are well set forth in the January (1892) number of this Magazine, in the department of Architecture, and a fairly good method of utilizing gas for ventilation is therein described. But in the present state of the art of ventilation, and with the abundance of small motors now obtainable for driving ventilating-fans, any architect who does not avail himself of these resources for moving air to any extent and within any limits desired, in ventilating schools, churches, theaters and all large buildings wherein people congregate, is entirely behind the age.

Moreover the use of mechanical ventilation enables such buildings to be heated without the use of direct radiators, which are not in general

highly ornamental, and which occupy room desirable for other purposes. The heating and ventilation are accomplished simultaneously and at the minimum of cost. Much light upon this subject may be obtained from various articles published in previous numbers of this magazine. Some hints on the desirability of avoiding direct radiators may also be found in the June (1892) number in the department of Architecture.

A common thing, which always irritates heating engineers, is to find a corner room or a room with a bay window, in which the amount of glass in windows is in preposterously large proportion to the size of the room, and in which the only place possible for a radiator or a hot-air register, is at the inmost side—the farthest possible from the glass. Now although glass is a poor conductor of heat as compared with other materials used in building, it should be remembered that its thinness makes it by far the easiest passage for heat out of buildings of all the numerous substances used. *Glass is a hole to heat.* Now in case a much larger radiator is required to heat the space than would be needed were there less glass to rob the room of heat, even if the radiator could be placed on the cold side (the glass) of the inclosed space (and such a radiator will nearly always be objected to on account of its needful size, even if favorably placed) when located where the architect's plans demand, its size would be still further increased, and before the architect will cease to object to it, there is often an unpleasant argument between him and the contractor. To avoid this difficulty the cellar space should be extended in the plans under the bay in such manner as to permit the placing of one or more ample indirect radiators connected by short flues with a register or registers directly under the glass. This avoids the difficulty named and the architect may then be as lavish with his glass as his design demands. There will be no space occupied by radiators in the room to be heated, the heaters being in the cellar, and heating can thus be made very satisfactory.

I have, I think, shown the advisability of an early coöperation of the heating engineer with the architect. I could name an instance, if I chose, wherein an architect lost an excellent client, through failure to achieve satisfactory heating and ventilation of a building resulting from delaying to consider these problems until the building was so far advanced that the difficulties he had introduced were no longer surmountable. This was made entirely clear to the owner by the unvarying opinions and remonstrances of various heating engineers consulted. The architect thus lost the confidence of the owner, and suffered in reputation, whereas both of these disagreeable results might easily have been avoided.

ELECTRICITY.

Conducted by Franklin L. Pope.

IN the construction of central stations for electrical distribution a marked difference exists between American and European practice, not merely as to the types of machinery most in favor, but in respect to the methods of distribution and regulation employed. The American practice has been to "standardize" a machine or system of circuits as soon as its practicality has been established satisfactorily, and the standard types determined upon are thereafter adhered to as closely as possible, while in Europe there appears to be no such thing as a "standard practice." Every new installation is almost sure to differ in many details from its predecessors, and it is a notable exception to find two stations having a similar equipment. In this country the commercial aspect of the matter is the controlling one, while in Europe much more scope is permitted to individual engineering ability. A great deal might be said on both sides of this question. We think it was Professor Silvanus Thompson who classified electric arc-lamps under the three heads of "engineer's," "clockmaker's," and "sewing-machine" lamps. But it will be noted that the last named, which is preëminently the American type of lamp, has pretty nearly crowded the others from the field in every part of the world. Whether this result will ultimately follow in other classes of electric machinery remains to be seen.

The enormous development of the electric-lighting industry which has taken place in London during the past year has been a matter of no small surprise to visiting American electricians. A correspondent of the *Electrical World* states that there are now about twenty central stations in operation in London, nearly every one of which possesses important features peculiar to itself. One of the most successful of these is that in Lincoln's Inn Fields, which comprises a complete Westinghouse plant, including dynamos, converters, engines and boilers, imported from Pittsburgh and set up by American engineers and mechanics. This was almost the first of these undertakings started in London, and, although it has been the subject of not a little adverse professional criticism, has done its work admirably from the hour that the first wheel was turned. Nearly all the central-station plants make use of the storage battery in one way or another. There appears to be the greatest diversity of opinion as to which of the various methods adopted is giving the best results.

Great progress is being made in the introduction of incandescent electric-lighting in Paris. The system of distribution which is in use is peculiar, being dependent altogether upon storage batteries. The proportion of lamps supplied direct from the generators is comparatively insignificant. During the time of heaviest load, from 4 P. M. until the following morning, the engines and dynamos are not run, the lamps being fed entirely from the storage cells. Nearly 100,000 lamps are now supplied in Paris in this way. A noteworthy feature is the unusually large size of the cells, each cell containing from fifteen to twenty-five plates weighing about 44 pounds each. These are grouped as required, in local distributing-stations at convenient points, and are charged during the day through underground mains from the central station. This system of distribution was introduced as long ago as 1883 by the Brush-Swan Electrical Light Co., of Cheyenne, Wyoming, under the management of Mr. E. P. Roberts, but ultimately had to be abandoned on account of the imperfections which were inherent in the storage batteries of that date. The company manufacturing the batteries used in Paris is understood to guarantee an efficiency of 63 per cent., but careful tests

have shown in some of the stations an average efficiency as high as 72 to 85 per cent.

The electric lighting of London has been allotted to companies operating within certain specified geographical districts, there being as a rule two companies authorized in each district, in order to preserve a healthful degree of competition. The returns of January 1, 1892, show that most gratifying progress has been made, the number of lamps in connection by the different companies being as follows: Metropolitan Electric Supply, 82,000; Westminster, 62,000; St. James and Pall Mall, 38,000; Kensington and Knightsbridge, 38,000; Chelsea, 28,000; House-to-House, 19,000, and Notting Hill, 3000. These figures, we presume, are on an 8-candle lamp basis, and for comparison with the 16-candle lamp basis employed in this country, should be divided by two. It is stated that mains have already been laid in London within reach of 3,000,000 consumers.

The Chelsea Electricity Supply Co. of London has been using for nearly three years a system of distribution by continuous-current transformers, an apparatus which may best be described as a motor-generator, placed either on the premises of the consumer or at a sub-station. It is driven by a high-pressure continuous current, while the generating part gives out a low-pressure current for lighting. At a recent annual meeting of this company the chairman stated that the apparatus had always worked steadily and effectively and that the cost of maintenance had been very low.

IT looks very much as if the use of electricity as an illuminant for lighthouses would have to be definitively abandoned. The earliest practical application ever made of the electric light was at the lighthouse at La Hève on the coast of France in 1863, at which point, as well as at a number of others, it has ever since been in use. It has been proposed by the French government to apply it to many other lighthouses, but the emphatic protests and complaints which have been made have induced it to reconsider the matter. The opinion of practical navigators in England and in this country appears to be substantially in accord, to the effect that the electric lamps are much less easily seen in foggy and hazy weather than oil lamps of corresponding power, while serious complaints are made of the blinding glare which the electric light throws upon the surface of the water in its immediate vicinity. It was this objection that led to the abolition of the electric light established at the Hell-Gate entrance of New York harbor, some years since. It will be noted that these criticisms really apply only to the arc light. It seems not at all improbable that the incandescent or semi-incandescent lamp may yet be successfully applied to lighthouse purposes.

AT a recent meeting of the Institute of Electrical Engineers a very instructive discussion took place on the subject of electric street-car motors. The advantages and disadvantages of geared motors were debated *pro* and *con*, but the absence of data derived from actual experience precluded any definite conclusion being reached. One speaker pointed out that the real difficulty in street-car work is to get a high efficiency under average conditions. Each car is compelled to run on a given route and time-schedule, and the car that will perform its allotted service with the least consumption of electric energy (repairs being equal) is the most efficient to the railroad company. There appears to be a great difference between the different types of motors now in use in this respect. It was asserted without contradiction, that with some types of motor on an average road, twelve cars could be operated with a 100 kilo-watt dynamo, whereas with other types, only eight, six and even five cars could be run with the same power. It makes some difference both in capital and expense account whether one or two 100 kilo-watt dynamos must be installed to do a certain amount of work, and it would certainly appear that the problem must be taken into serious consideration by railroad companies. Another speaker mentioned a test

of a gearless motor on the West-End railway in Boston, which had shown the remarkable efficiency of 80 per cent. It appears to have been generally conceded that, other things being equal, the higher the speed of the car, the greater the economy.

An electric street-car ought to earn at least 15 cents per mile run in order to pay 5 per cent. on the investment necessary at the present cost of construction and operation of such roads. This estimate does not include the cost of the franchise, which is of course indeterminate. Assuming a car to run 110 miles per day, about 330 fares at 5 cents each would need to be taken in to reach the figure named. The number of street-car journeys per capita per annum is greater in Boston than in any city in the United States, being 179 as against 144 in New York, 157 in Philadelphia and 126 in Brooklyn. Experience has shown that the substitution of electricity for horses on a street railway has been followed invariably by an increase in gross receipts, seldom less than 30 per cent., and in some instances as great as 300 per cent. In most cases the operating expense per car-mile has been reduced at the same time.

Experiments made to determine the power required to propel a street-car by inserting a Salter's balance between the horses and the car showed the starting effort to vary from 100 to 200 pounds per ton weight of the car, while the running effort was only about 25 pounds per ton.

A CORRESPONDENT of the *Electrical World* gives some recent and apparently trustworthy information respecting the working of the conduit electric railway system constructed in Budapest in 1889 by Siemens & Halske, of Berlin. There are four lines having an aggregate length of about twelve miles. The maximum grade is 1.6 per cent. There are fifty-three motor and eight trail cars, the former weighing 4.8 tons each (empty), each fitted with a chain-geared 16 horse-power motor. The conduit is under one of the rails, and has a slot 1½ inches wide, which by the way would not answer at all with such vehicle-wheels as are commonly used in this country. The central-station dynamos are shunt-wound, and the system is worked at a pressure of 300 volts. In rainy weather, or during the time of melting snow, at which times the drainage of the conduit is said to be inadequate, the loss by leakage is quite appreciable. It may be remarked that Budapest is credited with having the best kept streets of any city in the world, an important point in the successful operation of such a system. The cost of the line is given by the constructors at about $37,000 per mile. The weakest point in the system seems to be the traveling contact-devices, most of the interruptions reported being due to the breakage or disarrangement of these appendages. It is said, apparently upon good authority, that the same system is about to be tried in this country.

Engineer Westernholtz of Siam, who has been studying the question of electric transportation in Europe and America, has contracted for a complete outfit for the eight miles of the Bangkok Tramways Co., and the material is now being shipped. It will be a trifle amusing if Bangkok achieves electric transportation with American machinery before Philadelphia does.

It is to be hoped the electric railway in Bankok will be more successful than the electric-lighting company of that oriental capital, which was organized last year mainly with British money, and which erected an extensive plant at a cost of nearly $250,000, but has already been compelled to go into liquidation. A local journal observes that the "miserable bungling" of the company's affairs "only affords another melancholy example of the incapacity of the native mind to grapple with the fine art of company management." It is nevertheless believed that if wholly freed from Siamese management and control, as it probably will be under the reorganized condition of affairs, the enterprise is likely to become a very profitable one.

A CENSUS of the manufacturing industries of Switzerland made last year showed that there were altogether 2359 mechanical establishments, utilizing a horse-power of 54,243 of water, 27,432 of steam, 394 of gas and 332 of electricity; but this it seems

does not include several thousand additional horse-power which does not come under the factory act. More than $5,000,000 are sent abroad for coal and nearly one-fourth as much more for petroleum. A distinguished engineer of Berne computes that there exists more than 600,000 horse-power of water-power in Switzerland, unemployed but readily available. It is of interest to compare these figures with those of Massachusetts as given in the State census report of 1885. There were 4317 steam-engines of a rated capacity of 301,318 horse-power and actually using 238,672 horse-power, 2576 water-wheels rated at 149,906 and using 126,339 horse-power; and 22 electric motors aggregating 58 horse-power. Electric power in 1885 was therefore a little behind windmills, of which there were twenty-three having an estimated horse-power of 68½. It is evident that the natural resources of Switzerland may yet be developed by means of the electric motor, to the extent of making her one of the foremost manufacturing countries in Europe. It is perhaps not generally known that the amount of utilized water-power upon the Connecticut river, including its tributaries, is considerably greater than that of any other river in the world, the total amount being no less than 118,000 horse-power.

GROUND has been broken recently for the erection in Cleveland, Ohio, of an enormous establishment to be devoted solely to the manufacture of arc-light carbons. One hundred acres of land have been secured, and thirty acres of buildings will be put up this year, having a capacity of half a million carbons per day and giving employment to 1000 hands. The enormous consumption of raw material in this industry has already advanced the price of coke from $10 per ton to $15, thus indirectly adding in no small measure to the profits of the gas business.

ONE of the largest electrical plants in the world is at the electro-chemical salt works at Vallorbes, Switzerland, and is operated by water-power. There are 10 150 volt dynamos of 160 horse-power each, besides two of 700 horse-power, a total of 3000 horse-power. Each dynamo is coupled to a single turbine, running at 350 revolutions per minute under a head of 220 feet. There is no regulation of any kind; nine machines are run day and night at full load, the tenth machine being held in reserve in case of emergency. The distance to which the current is transmitted is about two miles. The installation, including land, buildings and machinery, is said to have cost approximately $40 per horse-power, and has been in successful operation nearly two years.

IN one of the Comstock mines at Virginia City, Nev., an electric plant has recently been installed of a somewhat remarkable character. A Pelton water-wheel, composed of a steel disk thirty-six inches in diameter with riveted buckets, weighing only 180 pounds in all, is driven by the impact of a half-inch stream of water under a vertical head of 2100 feet, running at 1150 revolutions per minute and developing about 100 horse-power. This wheel is connected directly to the dynamo. The wheel jet is said to resist the blow of a sledge like a solid steel bar.

Plans are being made for the construction of an immense hydraulic-electric plant at the Chambly rapids on the Richelieu river, P. Q., at which point 25,000 horse-power are said to be available at the lowest stage of water. This power will be converted into electricity and transmitted by wire to Montreal to be used by the Royal Electric Co., of that city, for light and power. The necessary authorization of the Dominion government has been obtained, and work is to be commenced at once.

M. D' ARSONVAL has been studying the *Gymnotus electricus*, of which he possesses a specimen capable of emitting a current, or rather a discharge, of 100 volts and 2 amperès, which can be made to magnetize an electro-magnet. The electrical apparatus is underneath the animal, the positive terminal being at its head and the negative at its tail. In striking its prey it folds itself into the arc of a circle and completes

an electric circuit through the body of the doomed animal. The *Gymnotus* is found in some of the South American rivers, and is ordinarily five or six feet in length, although occasional specimens are found very much larger.

M. PALAZ, in an article in *La Lumière Electrique*, states, as the result of numerous observations by different experimenters, that 85 per cent. of the light of an arc-lamp is emitted by the positive carbon, 10 per cent. by the negative carbon, and 5 per cent. only by the flame of the arc. Observations made by Mr. C. F. Higgins, of Finsbury Technical College, on a large lamp of 51 volts and 26 ampères, showed an illuminating power of 42,000 candle-power per square inch of positive carbon or "crater" surface.

IN the course of a recent discussion before the British Institution of Electrical Engineers, Mr. William H. Preece stated that while pure gutta-percha was cheap and abundant thirty years ago, when the trade was all in the hands of one firm, at the present day there was absolutely no unadulterated gutta-percha to be had in the market. He said that in instances within his knowledge, the use in a submarine cable of the sophisticated material had proved disastrous, the cable becoming wholly useless within three or four years.

EXPERIENCE shows that the life of incandescent lamps, particularly those having long thin filaments, is materially shortened by mounting them in either a horizontal position, or, as is frequently done, in a position upwardly inclined from the horizontal. This effect is especially noticeable in buildings subject to vibration from running machinery.

A WORK of reference of especial value, not only to the professional electrician but to the general scientific reader, is the new and enlarged edition of Professor E. J. Houston's Dictionary of Electrical Words, Terms and Phrases, just issued. It contains about 5000 titles and 570 illustrations, and appears to fully cover every branch of the subject.

WHILE the number of different types of dynamo-electric machines which have been successfully applied to incandescent lighting is literally legion, it is a most remarkable circumstance that the two earliest successful types of arc-light dynamos, those of Brush and Thomson-Houston, have easily maintained their lead against all competitors, although no material modification or improvement in principle has been made in either from the beginning. Professor Silvanus Thompson estimates, and we think correctly, that three-quarters of all the arc lights in the world to-day are run by one or the other of these two machines. It is said that nearly 150,000 arc lamps have been made under the patent of a single company.

ONE of the long-felt wants in submarine telegraphy has been a repeating apparatus capable of accurately transferring the peculiar undulatory signals from one circuit to another. This has at length been effected by the recent invention of a variable resistance carbon relay, which is said to give admirable results in practice. This improvement ought to largely reduce the expense of operating long lines of cable communication, as for example between England and India, by doing away with the present necessity of manual repetition at the intermediate stations, not to mention the diminished liability to the errors of retransmission, which now give rise to more or less vexation and loss of time.

ACCORDING to Mr. Goschen, the average profit in every £1 of receipts of the British Post-Office Telegraphs for the last five years has been 3d, the expenses having been 19s. 9d. During the preceding five years, before the rate was reduced from 1s. to 6d., the expense was 18s. 6d. and the profit 1s. 6d.

PROF. W. E. AYRTON announces that as a result of exhaustive experiments and computations, he finds that a tailor's goose can be properly heated by electricity for about twopence per hour, and that an omelette may be satisfactorily cooked by the same potent agency at a cost of one farthing.

ONE of the principal obstacles in the way of an intelligent adjudication of patent cases by the courts is the difficulty of instructing the untechnical mind in the intricacies of technical principles, processes and machinery. With respect to the average juryman, this difficulty was long since by common consent admitted to be insurmountable, and of late years patent cases almost invariably have been tried in equity proceedings before one or more judges, without the intervention of a jury. But it is too much to expect even the most learned and accomplished of judges to comprehend the mysteries of domesticated electricity without further instruction than can be imparted in the course of a week's argument by counsel, however eloquent and able. In a recent hearing before Judge Green of the United States Court in Trenton, N. J., involving one of Edison's most important patents—that for distributing electricity from a central station through a peculiarly-arranged system of conductors to ensure uniform electric pressure in all the lamps of an extended system, his counsel provided an elaborate and costly object lesson, by converting the court-room into a complete electrical central station equipped with full-sized apparatus in actual operation, and enabling the whole procedure of distributing and regulating electric currents to be seen and understood almost at a glance. We believe the electrical companies would find it profitable to employ a competent demonstrator to go about the country giving popular lectures, illustrated in this way, and thus, at least to some extent, dissipate the dense mists of ignorance and prejudice which envelope the minds of so many worthy people, and which have formed so serious an obstacle, in many instances, to the introduction of electrical appliances.

AN exceedingly ingenious and useful telephone outfit has been devised which is intended especially to facilitate inter-communication between the different departments of large mercantile and manufacturing establishments and the like. The apparatus, though small and compact, is most effective in operation. Standing upon a desk, it occupies scarcely more room than an inkstand, yet enables the occupant to signal and speak instantly to any particular person connected with the system without disturbing others. Arrangements are being made to furnish these outfits at a rental so moderate as to place them within the reach of almost any one. The Hotel Waldorf, now building in New York, is to be provided with a telephonic communication of this character between the office and every room in the house, and it seems probable that the use of the telephone in this class of services will become the rule rather than the exception.

ONE of the sensations of the electrical department of the Paris Exposition of 1878, was the exhibition by Gaston Planté of the wonderful results attainable by the accumulation of electricity in secondary cells. M. Planté had studied the subject exhaustively, and even at that early date had discovered and published pretty much all there is to know about lead secondary batteries, having by his experiments originated and developed a system of "formation" by which the storage capacity of the lead plates was greatly augmented. Subsequently Faure in France and Brush in America independently discovered that by applying lead oxide to the plates in the form of a paste, Planté's somewhat tedious and expensive process of formation might be dispensed with, and a larger bulk of oxide maintained in condition for action. Numerous minor improvements in the construction and arrangement of the plates have been patented and much litigation has resulted therefrom. In a very recent decision, Judge Coxe of the United States Circuit Court has affirmed the validity of the Swan patent for perforated plates, for holding the oxide in place. In another case some time ago, the same judge sustained the patent of Brush for pasted plates. The commercial importance of these decisions seems likely to be considerably diminished by the tendency in late years to revert to the Planté and other early types of cells, some of which are unquestionably giving excellent practical results.

MECHANICS

Conducted by Frederic R. Hutton.

A VERY striking difference in condition is presented by reason of the high price of fuel to the eastern engineer who visits the western district of the United States. Where coal for industrial purposes commands nearly twice the figure for which it can be bought on the Atlantic seaboard, there must be introduced several interesting features looking towards the economy of fuel in every plant of large size. The first of these is the necessity of the use of the condensing-engine whereever possible. The advantages of this engine appear in several distinct forms.

There is first, the thermodynamic and theoretical advantage by which is secured a higher efficiency of the steam which is used. With a given boiler-pressure securing a certain pressure of steam, as it enters the cylinder, the efficiency by the formula of each pound of steam used varies directly as the difference in the temperature between that steam as it enters and as it leaves the cylinder. It is obvious that when the final pressure is less than that of the atmosphere, this difference in temperature is larger and the efficiency of the fluid used so much the higher.

In the second place, the vacuum being counted from the line of atmospheric pressure or zero of the steam-gage pressures in the opposite direction from that in which the steam-pressures are counted, there is secured for a given cylinder area a greater mean-pressure during the stroke, because the steam- and vacuum-readings at any point of the stroke are added together to give the actual effort at that point. A cylinder of given size therefore either gives more horse-power, or, for a given horse-power, a cylinder of smaller diameter can be used. In either case we use less steam for a given work, and therefore burn less coal to make the necessary steam.

Whenever the water which is required to effect the condensation of the steam is precious it becomes worth while to arrange the plant so that the same water can be used over and over again. In the large plants in the mining regions in the open country it pays the engineer to plan for ponds where the warmed water used in condensation can be cooled to be used again. In cities, however, this pond arrangement becomes difficult to obtain, and therefore a more compact system has been worked out to enable the roof of the power-house to be used for storage and cooling of the condensing water. The general arrangement of these cooling tanks used at the power-houses of the San Francisco cable-railroads consists in a series of shallow sheet-iron tanks, slightly inclined, so that the water shall flow in a comparatively thin sheet from the upper end of one tank to the lower end, where it overflows into a second tank at the side of the first and inclined in the opposite direction, so that the water zigzags backward and forward in a few feet of height, and gathers in the bottom tank with a good deal of its initial heat dissipated. The water enters the system at 185° F., and is used for condensation at a temperature of about 80°.

Doubtless a very considerable element in the cooling is the vaporization of the hot flowing water, but the loss in this way is comparatively small, and a partial stream flowing through an inch-and-a-half pipe supplies all additional water which is needed for an engine of several hundred horse-power.

ANOTHER very interesting difference in the practice of mining engineering in the Rocky mountains and west of them attaches to their hydraulic engineering. In the East the problem is usually in the form involving reasonably large volumes of water but at comparatively low heads. In the West the problem is usually of

another form, involving amounts of water both large and small, but with very great heads. This difference of condition has brought the water-pressure engine into a use which it has not found near the seashore, as a means of utilizing the weight of water, and has also developed water-motors of a type different from the historic forms. The overshot water-wheel, having as its fundamental principle that the water should be laid upon its circumference without shock so as to act by its weight alone, is absurdly out of place where a very high head presents itself. The immense cost of massive structures of this sort again puts them out of the running in competition with the rapidly-revolving wheels of small diameter which are more adapted for the conditions of great pressure. The turbine wheel turning upon a vertical axis is again the less adapted to these high pressures of water, by reason of the fact that the pressure in most designs has either a very large component of the pressure acting downwards upon the foot-step of the wheel and shaft, or else the entire head acts in this disadvantageous way.

Here, however, if the turbine principle is the one which offers the greatest advantage, the proper method in which to apply it is by the use of two wheels turning upon a horizontal axis to which they are both attached, so that the pressure of the water or the longitudinal components of that pressure neutralize each other through the solid connecting shaft. This arrangement also has the advantage, in mills and other enterprises where the shafting to be driven is usually horizontal, that no bevel-gearing is required to transform the vertical rotation of the wheel-shaft to the horizontal rotation of the line-shaft. It costs, however, about as much as two wheels.

BUT to meet the conditions of the great pressures referred to there has been developed a wheel utilizing in part the principle of reaction upon which the turbine depends, but depending so largely as to dwarf the importance of the other principle upon the impulse idea. A jet of water issuing from a nozzle impinges upon cup-shaped buckets upon the periphery of a simple open-armed or solid-disk wheel revolving upon a horizontal axis supported in ordinary bearings. The water acts by its living force and not by its weight, except as the living force is dependent upon the weight of the water due to the head. The construction of the wheel and its corresponding cost becomes very much cheaper and simpler, and the impulse coming tangentially upon the wheel is without influence in increasing the stress upon the bearings. The entire effect passes to the production of rotation of the shaft to be driven.

The limitations to this form of wheel are imposed by the necessity for revolving at a very high rate of speed. Where for any reason this speed by reason of undue resistance becomes so low that there is an excess of water impinging on each bucket before it moved out of the way to be replaced by the next one, the efficiency of the wheel would fall correspondingly. There is some loss in any case from water failing to get into the buckets. But by proportioning the diameter of the wheel to the work to be done it is possible to secure high linear speeds of circumference even with not too great numbers of shaft revolutions.

An interesting application of this method is to be seen in the recent installation made by the leading manufacturer of wheels of this description on the Pacific slope. It is in the Comstock mines, of Virginia City, Nevada. A wheel thirty-six inches in diameter is made of a $\frac{3}{8}$-inch steel plate with the buckets riveted to its periphery and by a dove-tailed form of joint which shall secure the bucket against any danger from centrifugal force. The vertical head of water is 2100 feet, corresponding to a pressure of 911 pounds to the square inch. A nozzle tip $\frac{5}{32}$ of an inch in diameter, under this head, will give ten horse-power and one of $\frac{7}{32}$ is in use giving the twenty horse-power which is required for the work of the wheel under its present conditions, running a ventilating blower. The wheel is speeded with the resistance on to run at 1150 revolutions per minute, which velocity corresponds to a speed at the periphery of

120 miles per hour. When the load is off the wheels speed up to about twice this velocity.

Under these conditions, the 116 cubic feet per minute, which is called a miner's inch of water in the western hydraulic practice, is able to develop five horse-power. Or by another interesting comparison, one horse-power is given for every two pounds of metal in the wheel. With a half-inch nozzle the same wheel would give 100 horse-power. This exceedingly high head of water is possible by reason of the location of the wheel on the level of the Sutro tunnel, while the water-supply is carried down from the pipe line of the Gold Hill Water Company from the mouth of the mine.

An interesting possibility which is offered by these great elevations was illustrated also by the practice in the Chollar shaft on the Comstock lode, where the water is first taken over an impulse wheel on the surface for direct driving of mill machinery with 460 feet of head of water, and the outflow from the wheel is carried down the shaft to six similar wheels forty inches in diameter, having as their head of water the entire 1680 feet, from the top to the tunnel level. The lower wheels drive dynamos connected by wires up the shaft to motors upon the mill machinery. This makes a most interesting illustration of what might be called the principle of compounding in water-wheel practice.

As another industrial feature in the railroad practice which heavy grades entail, two interesting matters have presented themselves recently in connection with the hauling power up the hill, and the braking power down the hill. In handling trains against the great resistance of gravity, the engine-man finds it necessary to throw sand under the driving-wheels of the engine to increase the adhesion. Every one has noticed on the boiler of the usual American engine a dome-like structure or a trapezoidal box over the wheel-guards from which sand can be delivered by a pipe, to increase adhesion under the wheels. The difficulty with this system, where the sand is delivered by its own weight under the wheels, is that an excess is likely to be discharged which will increase materially under the other cars of the train the resistance to hauling which the engine has to overcome. A recent improvement has been to apply through a comparatively small pipe the compressed air from the train-brake system to the delivery in small quantities of just the necessary amount of sand for adhesion without discharging the undesirable excess which would give trouble under the wheels other than the drivers.

The other expedient seems to offer some advantages in coming down the hills where the grade may reach over 100 feet to the mile. It is obvious in this case that a very long train may make very serious demands upon the air-supply, which the air-pump on the locomotive must furnish, if the brakes are to be put on under each car with the frequency which an alternating straight grade and resistant curve would offer. To accomplish the saving of air desired a relief valve is attached to the train-pipe of each car for these very steep grades, which can be opened by the trainman in charge at the head of such a grade, by which a pressure of sixteen pounds or so to the square-inch will be kept continuously upon the brake-shoe; the engineman being able on such parts of the line as this pressure will be enough to adjust the valve in the engine as for the release of the brakes, and by this means re-charge from the engine tank the brake reservoirs under each car, so that there shall be a reserve of power to be used when the demand arises. The danger of meeting a steep grade with too little reserve of brake power in the form of air at the necessary pressure is thus made more remote.

On one of the steep grades in the Rocky mountains where this difficulty may arise, a form of safety-device of great simplicity has been adopted. At the foot of a long incline, before striking a sharp curve, an open switch is located which can only be closed by the action of the watchman in charge of it. This switch runs off into a siding running up a very steep elevation, so that in case the train or a part of it should be beyond the control of the en-

gineer, he will simply run up this prohibitory hill and soon stop by the absorption of the momentum in overcoming the resistance of gravity. The watchman will only close the switch for the passage of the train when the train is brought to a standstill, in advance of it, thus convincing him that the engine-man has it under perfect control.

IT is interesting to observe the gradual passage of avocations which have been for years considered the special field of the hand laborer into that still broader field which is covered by machine-tools. Perhaps in no other department is this as striking as in the machinery now coming into use for the dressing and shaping of stone. This has always hitherto been given over to the mallet and chisel of the high-priced operative, and it is not so many years since the first introduction of the saw as a means of cutting out the special shapes required for lintels, stairs and side-walk paving. Recently, however, for the special requirements of lintels and cornices, a form of machine has been put into use based upon the design of the planers used in the machine-shops, but carrying a series of cutting-tools arranged somewhat like the sectional cutters which are used in the working out of moldings in a molding-machine. The stone to be dressed is secured to a reciprocating bed and the series of tools, each bearing a part of the required profile, are mounted upon a transverse rail and are fed down as the work progresses. This course is especially applicable for the softer varieties of stone, such as marbles, slates and sandstones. For sawing in the harder varieties satisfactory results are obtained from the use of diamonds inserted in the periphery of a steel disk. The work is done more rapidly than it was with the old-fashioned plan of a simple disk with abrasive powder or sand, and a more satisfactory result is obtained.

An interesting extension of this same department of work has been developed recently for the particular variety of stone-dressing to be used where fine carving is sought. It is an extension of the principle of the electric rock-drill. A comparatively finely-pointed chisel reciprocates very rapidly within an electrical coil, alternately excited and shut off and the downward impact produces the incision into the stone as guided by the hand of the artist. The blows of course succeed each other with great rapidity, much increasing the capacity of a given man during his working day, and of course correspondingly diminishing the cost of the product.

THE recent outbreak in several large engine-rooms of a rampant form of centrifugal force has directed anew the attention of designers of large engines to the formidable opponent which may sometimes attack their best-conceived designs. It has been the practice in many textile mills throughout New England to drive the different departments of the mill by several belts, three or more, passing from the large belt-wheel on the engine shaft, which also usually acts as a fly-wheel. These belts are perhaps forty inches in width, and three of them necessitate a very wide face to the pulley which may carry them without interfering. They will be upwards of thirty feet in diameter in order to secure a high lineal speed of the driving belts without too rapid a speed of the engine-shaft, and with such large diameters there are all the difficulties which attach to the use of cast iron for this purpose. The wheels must be in segments by reason, first of their great weight, making it impossible or difficult to shape and handle them all in one piece, and because the problems of their erection and transportation would become almost impossible of solution.

A wheel much over eleven feet in diameter cannot be shipped by rail by reason of its interfering with passenger trains or overhead structures according as it is shipped flat or edgewise. It is not an easy matter, moreover, to get around the difficulties which flow from the shrinking at unequal rates of the arm and continuous rim. It is the limitation set by this peculiarity of cast-iron in cooling which compels the universal use of curved arms where the rim is continuous. With a heavy rim, the arms would be in compression by the later cooling of the large mass in the rim,

but in a wide-faced wheel of thin rim, the arms would be in tension due to their cooling at a slower rate than the thin rim with its great radiating surface. A solid wheel is also very likely to have defects appear at the junction of the arms and rim, inasmuch as the solidification from the outside to the inside is very apt to result in a porous or spongy center, having, of course, little or no tensile resistance to the strains which act upon its area at that point.

The second design is to make the wheel in two pieces, bolting the rim and the hub together in halves by bolts in flanges. The third plan is to make the wheel in many segments, each arm being cast with a part of the rim and solid with it, so that the joints in the rim come between the arms, or else the arms and the rim are entirely separate; the rim being made continuous by bolts which fasten its segments to pads on the ends of each arm.

One advantage of this design is that the rim can then be made so as to have its centrifugal resistance more exactly calculable, and it can be made strong enough to stand up to do its work without the reinforcement of the arms at all.

THE recent accidents referred to have given prominence to two methods for mitigating the possibilities of the disasters which would come from the presence of hidden defects in the cast-iron work of which the wheel is made. The first of these is the one proposed and carried out by Mr. Charles H. Manning, at the Amoskeag Mills, in Manchester, New Hampshire, where the fly-wheel, which is also the belt-wheel, is a wooden-rimmed wheel with cast-iron radial spokes. The advantage which flows from the use of wood is that its greater lightness per cubic foot materially diminishes the resistance to be opposed to centrifugal force, while the tensile strength increases more rapidly than the centrifugal acceleration. An interesting description of the design and of the special appliances used by Mr. Manning in the construction and erection piecemeal of the large wheel was recently presented before the American Society of Mechanical Engineers.

The other form of large wheel of a composite type involves the use of hollow arms to the wheel within which are wrought-iron or steel bolts running from the hub to the rim, and resisting by the high tensile strength of those ductile metals the centrifugal force generated in the rapidly moving rim. While an ingenious inventor has patented the plan of casting into the rim and hub concentric rings of a tenacious metal from which similar metallic spokes joining the two rings shall be surrounded by the cast metal which forms the bearing surface of the hub and rim, yet there are practical difficulties connected with the unequal elasticity and contractibility of these different metals which make it questionable at present whether this scheme, practicable on a small scale, can be applied in any large way.

THE ordinary observer of military pageants and the museum collections of ordnance is apt to form inadequate ideas as to the requirements of the tools which must form the outfit of an establishment aiming to do the work required upon the modern gun of large bore. In the first place, the ordinary siege gun, intended to be more or less portable, is only a rifled gun in the newer practice, and is not aimed to carry either the great weights or the high explosives which the new guns require. There has recently been constructed for the Navy Yard at Washington a form of gun-lathe for turning and boring the sixteen-inch breech-loading rifles which it is the intention of the Ordnance Department to turn out as a standard design. Some conception of the magnitude of the tool can be gathered from its dimensions, which show a bed nearly 74 feet long, 9 feet wide and 2 feet deep. The main spindle at the head of the lathe has a length of 6 feet 9 inches between the centers of the bearings, and the bearings are 20 inches in diameter and 32 inches long for the front and where the greatest weight is to be borne, and 14 inches in diameter by 24 inches at the farther end. The set of cone pulleys are so adjusted that fourteen different speeds can be secured with a safe cutting pressure of 140,000 pounds on a diameter of 50 inches.

The capacity over the carriage is for 70 inches diameter. A very perfect system of feed-gears by which the longitudinal and transverse feeds can be adjusted to each other enables the necessary tapers to be turned with the simplest computations of the change wheels, and a longitudinal feed as high as three inches is provided for. There are two carriages, and the boring attachment is so that the labor of several men can be utilized at one time upon the massive work in progress. To prevent any deformation of the long gun, there are steady rests, four in number, which are carried by pushing or pulling from the tool carriage. The belt required for driving the spindle is eight inches wide and of double thickness.

AMONG the various suggestions which have been offered for the preservation of exposed metal work forming a part of modern structures, one of the most recent is the covering of the iron with aluminum electrically deposited. Among the first examples of this work on a large scale are the massive iron castings which are to form the superstructure for the Philadelphia City-Hall tower, and two of the six-ton columns have been so far completed. The depositing tanks are five in number, the first containing a solution of caustic soda, in which the column remains twenty-four hours to remove all grease.

The second is the pickling tank for the removal of scale and oxide, which are thoroughly removed after pickling, by steel brushes before it passes into the third or copper tank. In the fourth tank where it remains for three days, it receives a heavy copper deposit on the outside of which the final coating of one-sixteenth of an inch in thickness of aluminum attaches itself to the copper. Fifty pounds of aluminum go to each column, after which it is thoroughly washed in hot water, and the process is completed. To secure perfect uniformity of the coating, the castings are turned every two hours during their submergence in the electro-plating tank. This work was done by the Tacony Iron and Metal Company, to whose President, Mr. Francis Schumann, the credit of the work mainly attaches.

FOR the stopping and starting of machinery which it is desirable occasionally to disengage from a continuously running source of power, the device known as the clutch is often inapplicable. The positive jaw clutch has the disadvantage that a great strain is entailed at high speeds to change the velocity of the stationary machinery to be driven from its velocity zero, when it is at rest, to that of the moving elements in an instant of time. For this reason, the clutches of the friction type have great advantages in view of their distributing the work of engagement over a perceptible interval, so that the inertia is gradually overcome instead of being overcome with a suddenness which amounts to a shock of perhaps great intensity. The great difficulty connected with very many of these clutches is that when they have been engaged, and the work of the power is passing through them, it takes an enormous mechanical advantage to throw them out of gear. It will easily be seen by a moment's thought why this should be so; inasmuch as if the horse-power or foot-pounds passing through the clutch be divided by the speed in feet per minute, the quotient is the pounds with which the parts of the clutch will be jammed together. Centrifugal force, also, at high speeds sometimes acts as a very considerable influence to make disengagement difficult. For this reason, a design of clutch involving the cam principle for engagement of its friction surfaces offers an undoubted advantage, the disengaging lever moving the cam, and thereby engaging or releasing the *leverage*, by which the friction surfaces are seized. These problems of subdivided transmission become of moment in electric power stations and similar establishments where the principle of sub-division of power is not carried out, so that only so much of the plant need be run at any time as is necessary to meet the demand of the consumers.

ARCHITECTURE.

Conducted by Barr Ferree.

COMMENCEMENT season is over; the colleges and schools have closed, and the days of learning and of study for many thousands have reached a finality. Gay and joyous as Commencement week has come to be, it has a solemn side that should not be ignored. To many young men it means the exemption from a despotism of marks and petty insignificancies that should have no place in preparation for life; to others it typifies the beginning of things, the commencement of reality and of responsibility. Doubtless for all time to come there will be these two classes; they represent two great phases of human nature, and human nature is not a thing to be lightly changed or altered even in the passing of generations. We must accept it as such, and the most our educators can hope to accomplish is to reduce to a minimum all things which tend to make college days the emblem of bondage. This brings up at once the questions of methods and of matter. The unsuccessful teacher may spoil the most fascinating subject by his indifference or his incompetence; acceptable subjects will frequently rouse dormant enthusiasm where it may be least suspected. Unfortunately, while every one will admit the truth of these propositions, our current collegiate educational system is not based on such foundations. Certain studies are viewed as absolutely necessary to the well-being of every youth, and year after year, generation after generation, the same elementary ideas are drilled into our students without the smallest attention being given to the suggestions of modern thought, or the changes and improvements which modern ideas may not unreasonably be supposed to imply. On no other ground can the almost total exclusion of art teaching, the history of art and especially of architecture, be accounted for. Architecture is the oldest of the arts and the most useful; it is also one of the least understood at the present day. Some elementary teaching in its history, though not in its processes, should most certainly be included in the education of every well-rounded man. Aside from its importance as a useful subject, is its still greater importance as a means of training the mind through the eye. Modern education spares no means in order to train the intellect by feats of memory and mental exercises, but the value of eye-training seems not to be understood. Certainly it has small place in the higher education.

There have been many new "architects" turned out into the world during the last month—young men full of life and hope and dormant possibilities of accomplishing great things. But modern architecture is not an art that busies itself with the creation of monumental structures, with which great things in building are popularly associated. It is an eminently practical art, full of business and business responsibilities, with little space for imagination. Like most things of life there is little play in architecture, though those more fitted for it than others will take greater pleasure in it. There are few architects who do not now receive elementary training in the technical schools and the training offered in them becomes a matter of serious concern to those interested in the advancement of architecture in America. Omitting details of courses, though premising a close similarity in all, the subject of design may be taken as a fair test of the value of scholastic work in architecture. Glance over the lists of subjects in any of the architectural schools, and one will find façades of tragic theaters, presidential mansions, sumptuous residences, bridges with galleries over streets, memorial fountains, statues and pedestals, most of them proposed with unlimited means and the richest decorative features. Side by side with these go lesser

problems, as a day nursery, a country museum, a gardener's cottage, but these are minor episodes, introduced as a relief to the greater problems calling for more time, more experience, more knowledge, more invention; less utility, less practicability, less adaptability to every-day requirements. The great trouble with all our architectural schools is that, in design at least, they are modelled after the Ecole des Beaux Arts of Paris. It is quite true this is the greatest architectural school in the world, and that as a body French architects are at the top of the heap. But granted that this is so, neither of these things is a good or sufficient reason for blindly following the French system simply because it has produced the best possible results in France. As a matter of fact the architectural conditions in the two countries are totally different, while there is no similarity at all between the material offered for educational purposes. The students in the French school are men; those in America are boys.

The problems in design offered at the Ecole des Beaux Arts are frequently of most amazing complexity. Not only are they impossible monuments—structures that few architects would be called upon to design in the course of a very long practice—but the most extravagant freedom is permitted in matters of expense and decoration. The philosophy of this is simple enough; all manner of conditions massed in one problem will require so much ingenuity for a solution as to render lighter tasks extremely easy. The argument is not wholly convincing, but when its enormous practical success as shown in the history of modern French architecture, is taken into account it would seem to require an immense amount of courage for an architectural school to start on a different basis. Yet on a more utilitarian plan the coming great American school of architecture must be formulated. There must be less French work, intended for men of some maturity of thought and who have had the advantage of long training in draughtsmanship, not for boys still taking their first lessons in mechanical drawing. There will be less fancy designing and more practical work of a nature suited to American conditions and necessities. The time consumed in designing a monumental crematory with complicated outbuildings, imposing reception-rooms and a thousand costly details will never prepare the student for designing an actual crematory. It would be easy to cite instances. The exhibitions with which the architectural schools brought their work to a close last month were filled with drawings on the French plan, and very largely in the Renaissance style. It is not, perhaps, hard to trace the connection between the adaptability of the Renaissance to current necessities, of which we hear so much now-a-days, and its teaching in the schools. It would be strange indeed if a long training in the Renaissance did not leave an impression upon the youthful student's hand and mind which he would find hard to shake off in other work. Of course it is heresy of the rankest kind to suggest that the French system is not altogether the thing for American schools; it has accomplished too much good, we have too many good architects who were wholly trained by it. But why, if architecture is a practical art, consume valuable time in designing impossible structures under impossible conditions, and in a style that largely needs the help of the schools to keep it in vogue? Why, if the conditions of current architecture are of unsurpassed complexity, should not our young men begin to try to grasp them in the schools instead of waiting until an actual problem presents itself? There is much to be learned in the scholastic methods of architectural instruction: the demand for common sense in architecture is not less great in the schools, where the greatest amount should be found, than it is without.

A NEW building material which promises to be most serviceable to the architect is noted by the *American Architect*. Wired glass, as it is called, consists of sheets of glass or hollow glass vessels with a net work of fine wire imbedded in them. Apparently the wire is an alloy of some kind, since ordinary metal wires cannot be sealed permanently into glass. The process is said

to result in an amazing strengthening of the glass. Thus a sheet of the material heated to red heat and suddenly cooled with cold water will crack into innumerable pieces, which are so firmly held by the wires as to still be able to support a great weight. To this quality of being fire-proof is added that of being burglar-proof, since it can be cut only with extreme difficulty. If all that is claimed for it is true it would appear that this substance would speedily come into favor for sky-lights and even more exposed positions, its fire-proof and burglar-proof qualities rendering it available in almost every part of a building. Unfortunately the *American Architect* gives no particulars as to its inventors or any specific information concerning it. Doubtless its regard for the advertising value of editorial notices led to the suppression of the only really valuable information in connection with the matter. But a substance such as is described cannot remain hidden if it has the qualities claimed for it, and if it can be produced at reasonable cost.

AN Art Congress at Washington, though held with the avowed purpose of inducing Congress to repeal the odious tax on paintings which has disfigured our statute-books for a number of years, is a sign of the times that cannot be ignored. It was a proud and happy day for Miss Kate Field which saw the consummation of months of heavy work in the opening of the Art Congress and the accompanying exhibition of paintings. Probably no body of men stand so much in need of liberal art education, as a whole, as our Senators and Representatives, and with Miss Field as an educator the very greatest results may be anticipated. The prominence into which art matters have been brought by this agitation cannot but be beneficial to the whole country. There is no national quality so rudely glaring as our unappreciation of art and of beautiful things, and the more artistic subjects are talked about and written about and brought before the people the better it will be. We cannot have too much of it. The tariff and the silver question may grow tiresome at times, but art in all its forms offers an infinite variety that can never be wearisome. And so while the Washington Art Congress was more a meeting of painters and sculptors, because they were the classes most interested, the architects should not hesitate to recognize a kindred spirit and join with their brother workers in completing the work now so far advanced. Whether the Art Congress accomplishes its definite purpose or not, the interest it has excited, the discussions it has provoked, the works of art it has gathered together, and the entire earnestness with which it has used every available argument on the older Congress in session at the same time will do an immense amount of good. It is a most striking commentary on our artistic appreciation—and notwithstanding its shame, one we should keep before us as a reminder, we are no better than we should be—that a public meeting and discussion of artists was required to be held at the capital of this great country in order to induce our national legislators to introduce a little common sense into the regulations affecting the importation of works of art. We hear a good deal at times of American art for Americans, and sometimes we see a good deal of it, but a high art standard will never be developed among us, marvellous as are our intellectual and material resources, by excluding from our shores the great artistic works of other times and countries.

THE traditional life of the cat is not more prolonged than the fatal fascination that the evolution of a national American architecture has for many minds. Not very long ago a gentleman read a paper on this very subject before the Chicago Architectural Sketch Club which began with the amazing statement that "We have been told for many years that we ought to have an American style of architecture; and as I do not remember to have met any opposition to this proposal, it seems safe, therefore, to conclude that we are under obligations to have such a style." Chicago buildings give evidence of too much common sense for such nonsense to be tolerated there, however it may

be supported elsewhere. Nothing but the most total ignorance of the elements of architectural history, and an absolute blindness in observation, could have produced the remark just quoted. If the author of this sentence can wear the same kind and amount of clothing all the year round, live in the same manner, with the same exposure for the like period, if he will further undertake to induce the inhabitants of every State and Territory in our great country to think as he does on this subject, and will supply a uniformity of building materials throughout the same region, then in truth, and not till then, will we have a real and true "American" style of architecture. Not that our buildings must all be alike, but our climatic conditions are so varied, our manners of living so diverse, our habits of thought so different that unless some wider common basis than we know gives evidence of forthcoming all the essayists and writers and lecturers in the world will not evolve for us an architectural style we can call national. It is only those whose nationality is limited by the horizon of their study windows, who forget that America is not a narrow strip of land on the Atlantic coast or around the great lakes, who can promulgate such things. As a matter of fact it doesn't matter at all whether we have an "American" style or not, so long as we build well and to the purpose.

BERLIN, like New York, is to have its cathedral, a vote to that purpose having recently been granted by the Prussian Diet, though not without much opposition. This opposition arose not only from the ground of unnecessary expenditure, but also, it is refreshing to note, from the unpopularity of the selected design. Such a feeling exhibits a most healthy interest in architectural matters which we in this country are sadly in need of. The chosen design is in the Renaissance style with a great dome as the central feature. These elements were much talked of when the designs for the Episcopal Cathedral of New York were awaiting final decision, and the doctors were free in advising that on such lines alone could a "modern" cathedral be designed. While it goes without saying that the Berlin cathedral might have been a happier composition, it certainly points a warning of what we might have had had the doctors been allowed to have their way. New York is by no means to be congratulated on the design finally selected for its own great church, but as it is proposed to spread its erection over a long term of years, and as the Trustees announce their willingness to admit all sorts of modifications, there is hope that a really fine building may be erected in the end. The trouble with the New York cathedral, and the same remark applies to that of Berlin, is the comparisons that will necessarily be made between it and the mediæval cathedrals. The idea to eclipse, or at least equal, these marvels of architecture, seems to have been the fundamental thought of those having the matter in charge. In itself the idea is not bad, but the conditions under which an American cathedral must be built differ so widely from those under which the mediæval cathedrals were erected that unless we bodily transport one of them to our country it is hard to see how we can escape failure. Failure is a harsh word to use towards the energetic men who have the matter in charge, but it is impossible to escape making comparisons, and it is equally impossible to help seeing that such comparisons must inevitably be unfavorable to the American edifice. It is unfortunate that such should be the case, but a cathedral is a cathedral, and it will be impossible to think of New York without calling to mind those glorious buildings of which Paris, and Chartres and Reims and Amiens are imperishable examples.

THE building of college buildings has so frequently proved the ruin of young colleges that the action of the trustees of Columbia College in deferring all plans for buildings on their new site to a commission composed of well-known New York architects and professional representatives from the faculty is entirely to be commended. And not the less so because as yet scarcely a penny is in hand to provide

new structures of any kind. It is a significant sign of the times when our educational bodies look upon the possibilities of architectural situation in planning a fresh group of structures on a new site. Too often such questions are left to settle themselves and posterity saddled with a heterogeneous collection of ideas that may become picturesque in time, but which in no way illustrate the architectural thought of the period in which they were built. There will be none of this in the new buildings Columbia proposes to erect. The land it has acquired above the site of the Episcopal Cathedral is one of the finest locations in the metropolis. Here, better than elsewhere within the narrow limits of Manhattan Island, can an imposing group of structures be erected which shall be not only an adornment to the city but a striking memorial to the intelligence, taste and foresight of the men who planned them, and who, if they are not able individually to carry out their designs, will have laid a foundation of thorough excellence. It need scarcely be said, from the manner in which the Columbia trustees are proceeding with their work, that in time they will give us the most successful group of college buildings in the country. Certainly their evident plan to proceed with the whole work on one central idea, as is indicated by the formation of the Architectural Commission, is a most striking advance upon the architectural methods of other colleges, in which buildings have been built as they were needed, in almost every style and fashion, as means and time permitted. All of this has been well enough in its way, because the older colleges date from what may be termed, at least so far as America is concerned, pre-architectural times. Columbia will work in a different manner, and the experiment of carrying out a general building idea over a period of years, as will undoubtedly be the case, will be watched with great interest. It will be a matter of regret if the other colleges and institutions of learning that are meditating removal to adjacent sites do not coalesce with Columbia and thus unite resources which are now unwisely disconnected. The scholastic possibilities from the union of all of the higher institutions of New York under the head of Columbia College and their transference to a new site are not less great than the architectural possibilities.

THEATERS and theater-planning have been receiving marked attention from English architects in the last few months, several noteworthy papers on these subjects having been recently read before the architectural societies of London. It is natural that such should be the case, for few modern buildings have experienced as many changes and so well illustrate modern architectural ideas as theaters. As buildings they form a distinctly modern group, antiquity and the middle ages offering nothing at all comparable to them, and they are thus not only the product of modern ideas, but may be termed exclusively modern buildings. A paper read by Mr. E. A. E. Woodrow before the Architectural Association of London was concerned entirely with the subject of Recent Developments of Theater-Planning. The author took up the questions of site, of exits, of entrances, of staircases, the auditorium, the stage, dressing-rooms, and other important parts of the theater-building. Without treating this topic historically at all he noted the improvements introduced in these parts in the most recent buildings. Though the reading of the paper was accompanied with numerous plans, sections and elevations, it is unfortunate that the author did not borrow some American drawings. He would have found fruitful themes in the theater of the Chicago Auditorium and also in the new Schiller Theater in the same city, by the same architects, which is now very rapidly approaching completion. In the Auditorium the old form of domed auditorium is displaced by a ceiling constructed on the speaking-trumpet principle, consisting of a series of expanding arches extending from the stage outwards. Not only is this a very great advance acoustically, but it offers opportunities for novelties in theater decoration that the architects of the building have most admirably taken advantage of. English architects

and writers on architecture are every day giving more and more attention to the architecture of America, but it scarcely seems excusable to ignore so important an innovation as that employed in the Chicago Auditorium in any discussion on recent developments in theater-planning.

A CURE for efflorescence on brick-work is chronicled by Mr. H. C. Standage in *The Builder*. No problem has seemed so difficult of solution as this. An eyesore of irremediable unpleasantness, it has baffled the skill of architects and chemists alike. Mr. Standage's remedy is a very simple one, being the application of a solution of common salt to the brick before being placed in position, or a thorough saturation afterwards. A porous brick will imbibe water in a rainfall and become impregnated with a solution of a salt of soda, from dissolving some of the sodium salts in the mortar. This, on drying, will become anhydrous sodic oxide if the weather be dry, or minute crystals if the weather be damp, in the latter case not becoming quite entirely anhydrous. Now if hydrochloric acid is applied to this oxide (Na O) the reaction will be water and chloride of sodium or common salt, which will, of course, dissolve in water. That is, chemically, $2HCl + Na_2O = HO + 2NaCl$. Hydrochloric acid is, however, expensive and dangerous to apply, and common salt itself was found to produce the desired result. In this case the chemistry would be $NaCl + NaHO = Na_2O + HCl$. In this formula Na_2O is the body which it is desired to expel or change into another form. In the application of common salt (NaCl) the changes may be accounted for by a stronger combination existing between hydrogen and chlorine than between sodium and chlorine. Is is also probable that the chlorine in the salt (NaCl) which readily separates and unites with the hydrogen is the efflorescence, or sodic hydrate (NaHO), the simultaneous production of hydrochloric acid neutralizing the effect of the sodic oxide efflorescing. Certainly the remedy is an inexpensive one, and while the inventor of the method admits his experiments have only been carried on for a single year, it would seem to be quite worth trying on a larger scale by other operators.

THE bill to license architects, lately passed by the Legislature of New York, must have struck terror into many hearts. From time immemorial it has been the custom among certain grades of architects and architectural critics to attribute all the bad work of modern days to non-professional architects, to draughtsmen or other irresponsible persons who could not, of course, be expected to be provided with the developed wisdom of "real" architects. If these classes should be prevented from inflicting their monstrosities upon a long suffering public, it would be an interesting question as to whom would be held accountable for the architectural sins of coming years. Probably not even those who have been in the habit of putting forth this explanation of the queer things in current work had any true belief in it, but it was vastly convenient to have some tangible portion of the public upon whom, with some show of reason, could be saddled everything bad or disagreeable. As gargoyles the much despised non-professional filled a highly important place, and while the bill failed to receive the Governor's signature, the respite is likely to be brief, and will be sure to be missed.

THE New York *Sun* did some good service in a recent issue in explaining, with the aid of diagrams, the methods employed in building the great power-house of the Broadway cable-road at Houston street. By means of a double system of supports, one for the machinery floor, of brick, and the other of iron for the building proper, it is hoped to make the upper part of the structure available for business and office purposes. It is so seldom that problems of architectural construction are referred to by the daily press that the *Sun's* article is especially noticeable. Machinery vibrations have so long baffled the efforts of architects and engineers that the actual success of this great structure will mark a decided advance in the architecture of manufacturing establishments.

CIVIL ENGINEERING.

Conducted by T. Graham Gribble.

CHICAGO'S first elevated railroad was opened for traffic on June 6. It commences at Congress street and runs due south on the alley between State and Wabash avenues, to Twelfth street, from which point it diverges very slightly on to a purchased right of way to Thirty-ninth street, a distance of about 3½ miles. This is traversed in fourteen minutes including stoppages, some of them less than a quarter of a mile, or an average rate of travel of about fifteen miles per hour. The structure is of a substantial character consisting of plate girders and bracketed posts and reflects much credit on the engineer-in-chief, Mr. R. L. Sloan, and upon his assistants. Mr. Sloan was formerly chief engineer of the Manhattan railway of New York, and patentee of some of the earlier devices adopted in that system of construction. He has adhered in the main to the ordinary form of elevated railway, but has made his ironwork more massive than that of the previous works. No attempt has been made to obtain economic advantage by continuity of stress; the longitudinal girders, of which there is one under each rail, are all merely supported and free to expand by oval bolt-holes or else a sliding arrangement is made at every second bay, thus making every two girders continuous, but there is no reduction of area on that account. It is possible that some economy might have been obtained by continuity, but the foundations of Chicago being such as to produce appreciable settlements under all heavy structures, there would have been a possibility of continuous girders developing abnormal stresses due to settlement. The placing of a longitudinal girder directly under each rail obtains the maximum stiffness possible from the girder since there is then no deflection of the cross-ties. Testing the vibration of the columns by hand on the day of opening, there was scarcely any sensation of lateral vibration, and a very slight longitudinal vibration when the train was running straight forward, but when switching there was quite perceptible lateral vibration. In the former case the vibration was barely sufficient to shake off a row of water drops which were resting on the lower flange of the girder. In the latter case, when standing on the platform at Congress street, the vibration was almost as much as on some of the Manhattan stations. This lateral vibration might be diminished by forming the lateral bracing into a complete triangulation extending over the whole width of the structure. The total length to the World's Fair grounds, a distance of 7½ miles, will be double-track, but a third track will be added for the last 1½ miles. At the terminus adjoining the Transportation building of the World's Fair there will be three platforms and four tracks for marshaling trains. The signaling will be arranged so that each platform may serve for arrival and departure. The time from Congress street to the World's Fair grounds will be 32 minutes. A crossing will be made over the Illinois Central Railway by a bridge of 221½ feet span having 21 feet clear headway above the Illinois Central rails. This will be a handsome bow-string truss standing about 33 feet above the street, to allow for the Illinois Central to elevate its tracks twelve feet. There are no sharp curves as far as the line is opened but at the next street (Fortieth street), there will be two square corners to turn and one at Sixty-third street. Hitherto the curves have all been put in as plain circular arcs. Along the alley the ordinary angle-bar fish-plate is used but beyond that the Fisher bridge joint. The writer could not observe any difference of smoothness in passing over first one then the other. The rails are 90-pound rails, and the car-wheels of course perfectly true, but the rhythmic sound of

crossing the joints was just perceptible. The noise also, although very much less than that of the Manhattan railway, was sufficient to frighten the horses when directly underneath the structure. The noise is deadened as much as possible by interposing the timber cross-ties between rails and girders; vibration is at a minimum; rails are deep and well jointed; but there is noise yet

The position of the line in an alley where it traverses the heart of the city removes all possible objection to it on the part of the inhabitants on account of noise, and the horses will very soon become used to it. It is still, however, the aim of all who are attempting the solution of the rapid-transit problem to obtain such a structure and such means of operation that the transportation may be carried on in any thoroughfare. With regard to the noise it is possible that if wheels are adhered to, the rolling of iron on iron, which must always produce some noise, may be got rid of by the use of some less resonant but durable substance in the wheel-tires; the present system in all rolling-stock of concentrating the load on the trucks is also more noisy than a greater distribution of the load would be. The two chief objections of the public to elevated roads on the best streets are the noise and the lack of ornamental features in the structure. In the sliding railway the transit is almost noiseless, and possibly this system might be used with other than hydraulic propulsion.

Chicago's "L," which rejoices in the ponderous title of the "Chicago and South-Side Rapid-Transit Railroad Company," is the best sample of elevated railway yet produced, and although it may not entirely disarm the public objection to having its counterpart on the finer thoroughfares, every step forward helps towards the solution of the rapid-transit difficulty. We must hope to see throughout the country such an understanding arrived at between the civic corporations and the railway promoters that the acquisition of charters will not need to be obtained at the point of the bayonet or by means less reputable; we must also hope to see such financial arrangements possible as will permit of the great profits arising out of these franchises being devoted to the ornamentation of the structures rather than to the undue aggrandizement of the promoters' wealth. With regard to the coming World's Fair, the Chicago elevated railway has acquired all of the right of way to the Exposition with the exception of 2000 feet, and expects to be completed by the end of the year. The line is likely to be one of the most popular means of travel and will probably be taxed to its utmost capacity during the whole period of the Exposition. When extended further southwards, and when all of those districts become developed by its means, as they are likely to be just as they have been in New York, it is difficult to see how a double-track road will ever be able to handle the traffic which will come to it. It will be a repetition of the great "Humanity Packing Companies" of New York.

THE construction of the Lake-street elevated road at Chicago was recommenced the first week in June and was then about 1½ miles in length. The structure is of the usual type. It runs due west from the city and is intended to extend to the suburbs. It will possibly in future make connection with the alley elevated road which runs south of the World's Fair grounds and so encircle the city. Being on a street, the posts are arranged at the curbs of the sidewalks; cross-girders span the driveway with the usual head-room. Two longitudinal plate girders carry the center tracks but there will be room for two other tracks outside of these when the traffic demands it. The longitudinal girders are allowed room for expansion by a stirrup similar to that in use on the alley "L," which occurs at every fourth bay. The lateral bracing appears somewhat scanty for the structure as it will be, but possibly more may be intended before the road is in operation. Otherwise the work appears to be of a substantial character and well put together.

MR. MORISON'S bridge over the Missis-

sippi at Memphis, Tennessee, was opened with an ovation corresponding to its position among the great achievements of the day and corresponding also to its value to the city and country in developing their resources and establishing their trade centers. The bridge consists of a series of great spans one of which, the greatest, is a cantilever, and the others are trusses. The total length of bridging is 2597 feet, in five spans ranging from 226 to 790 feet. This half-mile of bridgework combines several principles of construction and novel methods of erection, but presents a symmetrical and very majestic appearance. The two most interesting features to engineers were the method of putting in the foundations and that of combining the cantilever type with the truss, in order to obtain a uniform headway; to maintain a clear waterway during erection, and to utilize the "building out" principle with narrow piers.

With regard to the foundations the method adopted was in the main that of the St. Louis and Forth bridges, but the river was too deep to use guides, as at St. Louis, for sinking the caissons. These were sunk by the pneumatic process, aligned by guide-ropes attached to anchors. In order to preserve the caissons from tilting and to prevent the rapidly accumulating silt from massing against it, an expedient was resorted to of sinking willow mattresses 200 x 400 feet over the site of the pier. The caissons were then sunk upon this level bed prepared for them and the portion of the mattress inside the pier cut away to permit the latter to descend in the usual way to a firm foundation. The piers stand upon clay and are built of granite. The comparison of the foundations with those of the St. Louis bridge is as follows:

	Below Low water.	Below High water.	Greatest Immersion.
Memphis.....	96.2	130	108
East St. Louis....	94.	135.5	109.7

The minimum headway prescribed was 75 feet above high water, which is maintained by the lower chord of the bridge throughout. The longest span is a cantilever of 790 feet having a peculiarly small depth at the pier as compared with its length. The cantilever arms are also very short as compared with the central independent truss. The object of this construction was to obtain the leverage necessary for building out the intermediate truss, without having recourse to high and wide towers. The adjacent span of 621 feet was built on a temporary trestle, termed in this country false work, and from its end the cantilever arm was built out in the ordinary manner. The weather was favorable to the enterprise throughout the construction. The surveys were made in 1885 and the drawings prepared in 1888. The sinking of the caissons was commenced in the fall of 1888. The last masonry was completed in April, 1891, and the erection of the iron work in February, 1891. The last span, the intermediate truss of the cantilever, was swung clear on April 23, 1892. The bridge is built for a single line of railway and is expected to prove of immense value to the trade of Memphis. The tests were made by a train of locomotives. Fifteen locomotives with tenders on the 790-feet cantilever produced a deflection of 4⅜ inches. This is a ratio of about $\frac{1}{2200}$ and represents a very stiff bridge.

The exact figures of cost have not yet been made public, but are between $2,500,000 and $3,000,000. It would seem from this that the cost of the foundations and granite piers must have been as much or more than that of the superstructure. The weight of the material in the latter, including the metal viaducts, is stated in the newspaper account to have been 9500 tons, which at $100 per ton erected would be under $1,000,000, leaving $1,500,000 to $2,000,000 for the piers. These figures are of course subject to correction, but if approximately accurate they point to the economy of using long spans. The men employed in the caissons were paid about $2 to $2.50 for three shifts of 45 minutes each in the twenty-four hours. Only four died from the "bends," but many more suffered from it.

Mr. Morison is already celebrated for six great bridges over the Missouri river and first made himself famous as the engineer

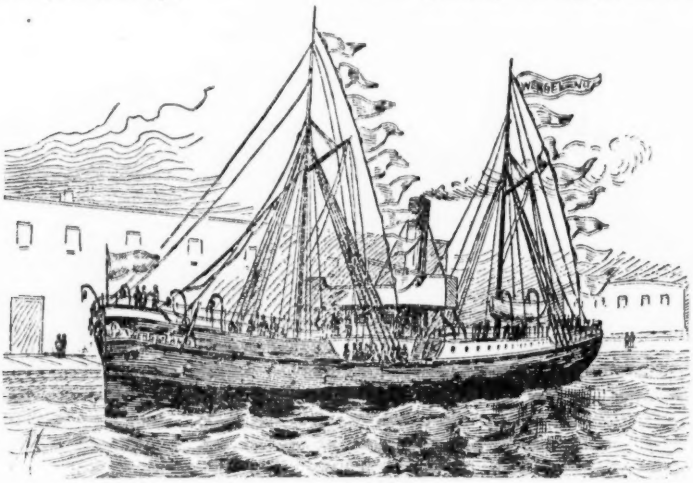
of the new Portage viaduct over the Genessee river. The old wooden structure being destroyed by fire, the new steel structure was put in its place in 100 days, a feat which probably has not ever yet been excelled in any country as regards rapidity of construction, and one which could only be accomplished in a country where bridge-building is systematized to the extent it is here. The resident engineer was Mr. Alfred Noble.

The principle of erection of the Memphis bridge is not so much a novelty as a novel combination of various methods to the desired end. In 1877 Mr. C. Shaler Smith built his justly-celebrated truss bridge over the Kentucky river entirely without false work, taking advantage of a pair of towers which had been previously erected with the intention of constructing a suspension bridge on the same site. He was enabled by means of those towers to build out for 196 feet. At this point temporary towers of wood were erected, and the corbeling out process continued until the intermediate permanent towers were reached. The bridge was a continuous truss in three spans of 375 feet each. The shore spans were, however, hinged after construction at the point of contrary flexure on Gerber's principle, thus making 75 feet of the shore span nearest to the tower into a cantilever arm. The total cost of this bridge was $404,000.

THE sewer work at the World's Fair will include about 64,000 feet of brick and pipe sewers from 6 inches to 3 feet 6 inches diameter. The Shone hydro-pneumatic system of Chicago, U. H. Broughton, engineer, is to be adopted. A plant capable of removing and chemically treating 10,000 gallons per minute will be erected.

THE standard type of plate girder bridges used upon the Swiss railway lately illustrated in the *Engineering News* is interesting to our engineers from its strong bearing upon the question of vibration. American bridge-building leads the world for economic and rapid construction. Nevertheless, the change in external conditions which the last quarter century has produced in this continent has modified the construction of bridges in some ways, and has to some extent occasioned a tendency to greater similarity with European practice. The Swiss bridge construction looks as if it had taken some hints from the exhaustive experiments for reducing vibration made on the Berliner Stadtbahn, which were described and illustrated in the *Street Railway Review* of Chicago about a year ago. A series of trough girders somewhat akin to the Lindsay flooring of England acts as rail-bearers and are filled with concrete in which the cross-ties are imbedded. It is admitted that this mode of construction makes the bridge 10 to 15 per cent. heavier, but it is claimed on the other hand that it reduces the vibration to a minimum. It is probable that as regards some of the lighter forms of construction in America to adopt such a roadway as this would make the bridge not 10 but 50 to 100 per cent. heavier, and yet if the bridge cost double at the outset it would probably have three or four times the life, for it is either vibration or corrosion which is the fatal disease of nearly all bridges. So large a proportion of bridges are still built to serve the transient but important office of booming new districts that there are few opportunities for building bridges with ballasted roadways. The type of Swiss construction and analogous methods are very well adapted to city bridges under heavy traffic, but there is another method of obtaining minimum vibration without increasing the weight which does not appear to have yet come into use. That is by the employment of deep rail-beams acting as continuous girders. Where cross-girders are placed, say 10 to 20 feet apart, it is possible *with the same amount of material in the rail-bearers* to obtain a local stiffness of from 8 to 27 times what is obtained by the ordinary construction. It is the same problem as that of the architect in getting a house floor combining maximum of economy and stiffness. It is easy to have two house floors of equal strength, and yet one will be from 8 to 27 times as vibratory as the other. The use of iron in bridges modifies the details of stiffening, but the principle is the same, and can be

much more effectually reduced to detail. The vibration of many a highway bridge which destroys the pins and causes the removal of the whole structure long before its time, especially in short spans, is not due to lack of stiffness in the main construction, but to the combination of a very inferior flooring which acts like a series of springs upon the main structural nodes and produces a wave-like motion analogous to that produced on unstiffened suspension bridges by the vertical component (small in itself) of wind pressure, but by gradual augmentation, extremely detrimental, if not destructive, to the bridge.



THE STEAMER "WERGELAND."

THE arrival of the first steam vessel bearing an old-country flag at the port of Chicago, via the St. Lawrence and Welland canals, may be considered a landmark in the history of the future "World's Highway." The *Wergeland*, steel propeller of 400 tons burden, arrived in Chicago on May 26, from Bergen, Norway, which port she left on April 12. She draws, when loaded, between thirteen and fourteen feet of water, and carried 30,000 barrels of herrings and a considerable quantity of cod-liver oil. She was received with an enthusiastic welcome from the Scandinavian citizens and a salvo of steam-whistles from all the vessels in the harbor. The only trouble experienced by her was in the St. Lawrence canals, where she was forced to unload the greater part of her cargo and send it by lighters from Montreal to Kingston. This added probably $1000 to the expense of the voyage. Her cargo was valued at $35,000, and was consigned to Mr. Thorp, of Chicago, who looks upon the voyage as, commercially, an experiment. She touched at Portland, England, on April 18, and at Surrey, Nova Scotia, on May 4, for coal, and arrived at Montreal on May 8, thus completing the total distance of 5100 miles, including all transhipments and detentions, in forty-four days, or about double the time she would have taken to traverse the same distance without obstructions. The extra cost would be chiefly in wages because during the detentions she would not require to burn so much coal as when under full steam.

The opinion is entertained by many that the Canadian Government is afraid of making the St. Lawrence improvements lest they should lose the freight which now travels westward from Montreal by rail. If so it can only be on account of the great influence which these railroad corporations exercise upon the Government. The Dominion itself would unlock thereby a floodgate to an interoceanic commerce, the dimensions of which it is impossible

for the greatest enthusiast to calcalate. This commerce would be not only Canadian, but in much greater bulk from United States ports, and a comparatively small toll would probably yield a handsome revenue on the investment besides opening up the Canadian lake ports all along the line.

If the successful advent of the *Wergeland* does no more, it will demonstrate that commerce is pressing hard against the physical barriers which still block the way in the natural channel from the old world into the heart of America. If Canada does not speedily undertake the St. Lawrence river improvements she may be left out in the cold by the United States. The cost of developing the Erie or Oswego canals would be immensely more than that of the St. Lawrence canals, but not proportionately more than the ratio of the wealth of the two nations. There would still be much more delay in lockage by the American route, but if it came to competition for a European commerce, the American route possessing an open waterway all through the winter and assisted by Government subsidies to enable the tolls to be reduced to competitive rates, might be made preferable to all old-country vessels bound for American inland ports.

THE first half-year's operation of the Port Huron and Sarnia tunnel appears to afford some useful data as regards the operation of the "Beach" or "Greathead" system of underground railways. The claim for the cylindrical form, approximating to the size of the rolling-stock, is that the latter acts like a piston and creates its own ventilation. In the South London electric railway, where there are two tunnels and the air is made to travel always in the same direction, the ventilation, though not as perfect as was expected, is sufficient to make the transit quite tolerable and very much to be preferred to the other metropolitan railways operated by steam. At the Port Huron and Sarnia tunnel of the Grand Trunk railway, where there is a single tunnel, it is reported that there is a difficulty in getting the train-men to work through it. Possibly if the United States laws permitted the company to bring over some of the train-hands of the London Metropolitan lines, they would thrive in it, but as it stands the company is going to introduce gas-consumers attached to the locomotives in addition to the 2-foot diameter ventilating-pipe with Root fans already there.

It is further claimed for this system that no settlements are possible in driving the shield, but on the Port Huron side a very unsightly crack was produced in a fine residence. It is probable that the greatest efficiency of this system would be produced by following the same general principles as for sewer ventilation, having upcast shafts at the highest points of the grade and by causing the air always to travel one way, but it is evident that subterranean travel has not yet attained perfection. For an underground railway of two tracks it has been considered a great point to be aimed at by some engineers to have numerous cross-over roads between the tracks, but if good ventilation is to be obtained, it will be needful either to cut off communication between the tracks except at the ventilating-stations or else to devise some other means of ventilation.

ON the 8th of June the largest vessel yet built for the lake traffic was launched in the Calumet river at South Chicago. She was christened the *Maritana*, is owned by the Minnesota Steamship Co., and is designed for the iron-ore trade. Her length of keel is 330 feet, length over all 348 feet, extreme breadth of beam 45 feet, and depth of hold 24½ feet. The engines will be triple-expansion, 24-, 39- and 63-inch diameters, with 48-inch stroke. Steam will be furnished at 160 pounds pressure from three 12x12 boilers. She is designed to carry a cargo of about 4000 tons on a draught of 14½ feet of water, and at an average speed of 14 miles per hour. Her cost was $250,000.

MINING AND METALLURGY.

Conducted by Albert Williams, Jr.

AN inventive friend contributes a series of design-sketches for an "aërial prospecting-car," which he suggests may come into use some time before the year 1912. He has been reading about Professor Langley's experiments and Mr. Maxim's practical progress toward aërial navigation, and quite naturally asks why this mode of travel should not be applied to prospecting as well as to anything else, thus saving the fatigue of climbing high mountains, bumping along on horseback or driving a pack burro. His drawings—it is regretted that they cannot be reproduced here—show an aëroplane driven by any suitable motor, with a propeller screw so connected by a universal joint as to steer the craft laterally and vertically, accommodating the course of flight to the inequalities of ground over which it skims, the prospector being comfortably seated in the car and looking out for croppings while he enjoys his pipe at ease. The machine is to be provided with adjustable stilts for alighting on uneven spots, and the aëroplane is to fold up when landing under trees. Another view exhibits the prospector leisurely examining, while in flight, the piece of float which he has just picked up, while he keeps the corner of one eye open for the ledge from which it came; and still another picture shows a whole fleet of these prospecting cars hovering over a new district where "every prospect pleases." Truly a sybaritic way of doing what in these primitive days is accomplished only by dint of the hardest kind of hard work.

THIS whimsical conceit, for of course it is only put forward as such, may be taken, however, as a jest in sober earnest, if we look into it a little. It even may be said to carry with it what might be called a great moral lesson. Prospecting in the Far West, as conducted hitherto, no matter at what hardships, privations and risks, nor with what zealous care, has been for the most part literally a skimming over of the surface, as is conclusively exemplified every once in a while by the finding of important ore deposits in and about old districts, in places where mining is now being carried on or has been abandoned, and where the country has been tramped over time and again by former prospectors. Witness Cripple Creek, which must have been gone over by many from the time of the first Pike's Peak rush; Copper Rock, in the near neighborhood of flourishing mining enterprises; Creede, just alongside the old abandoned Sunnyside district, and scores of other finds made in different parts of the mining regions during the last few years. Certainly an untrodden field presents advantages to the prospector, yet the territory nearer at home is never altogether exhausted. Prospectors generally have an antipathy to revisiting deserted camps, but it is fairly to be believed that in the numberless districts which in early days attracted transitory attention, were scratched over a little, and then given up after too hasty examination, there is still plenty of room for valuable finds. Or, take the case of some of the older camps, especially in Nevada and Utah, which came into being shortly after the first discoveries had given an impetus that sent prospectors searching far and wide, where discoveries were made of sufficient importance to lead to regular mining, often to considerable extent, whose sites are now marked only by wrecks of expensive hoisting-works and mills, and where after heavy losses the original owners gave up in despair. Is it so sure that even this amount of negative evidence is absolutely conclusive? In the neighborhood of Silver City, Idaho, are now to be seen two noteworthy illustrations among many which might be chosen as in point. One is the Delamar group of mines, discovered so many years after the occupa-

tion of the Owyhee region, showing that the ground in all the time since 1863 had not been thoroughly prospected even at the surface. The other is the recent rehabilitation of the Poorman mine, where reopening of the old workings and slight new work brought to light an important ore body which the former miners had missed by barely a few feet. When such occurrences are likely to be met with, as they so frequently are, in places still inhabited and where mining is being steadily prosecuted in the vicinity, it seems that at least equal chances might be looked for in some of the wholly deserted camps now so persistently shunned. Of course it is hardly the business of the prospector to attempt reopening old mines, and for this he seldom has the means; but he might, instead of regarding them as beacons warning him to keep away, accept them as evidence that at some former time enough was found there to encourage his predecessors in working. If the vicinage has lain under taboo for years, so much the better for the new-comer.

THEN, too, as to the reoccupation of abandoned mines or districts, there is a consideration entirely apart from the question of finding new ore bodies. In former times the metallurgic art was in a very imperfect stage, and many disappointments should be ascribed to this score rather than to failure of the mines, though this vital distinction is not always recognized. Crude attempts were often made to treat ores by the raw amalgamation process, which was wholly unsuited to them; or by amalgamation after dry-crushing and chloridizing-roasting, which might get out a fair percentage of the metal, but at a prohibitory cost. Or smelting-furnaces were built to work ores of a single mine or district which could not be profitably treated alone, the result being technical or commercial failure, commonly both. Concentration was seldom practised until a period comparatively recent, for at first in many cases there was no available market for the concentrates, and with inferior transportation facilities it was not then practicable to organize great smelting centers commanding a variety of ores and cheap fuel and flux, so that there was no great incentive for putting up concentration-works at mines where now they would make all the difference between profit and loss. A frightful amount of money was wasted in misdirected efforts to reduce ores on the spot, attested by the still remaining ruins of costly but inefficient metallurgical plant. These failures not only stopped mining in such places, and tended to disparage localities known to be mineral-bearing, but discouraged prospectors from further search in the same regions. There are to-day numbers of these deserted camps which prospectors fight shy of, avoiding them because of the notion that they have been tried and found wanting. Now that the conditions are so different, they are worth re-examining. With vastly cheaper supplies and some reduction in wages, with improved means of transportation either at once available or readily afforded by railway extension whenever enough is uncovered to promise a paying freight traffic, and more than all with the far better understanding of how to utilize ores to the most advantage, the situation is indeed changed. This amounts to the presentation of what corresponds to entirely new areas for prospecting; for besides the mines partially developed and then abandoned, the adjoining territory, long neglected in favor of newer fields, has hardly been touched.

THERE is still left in this country an enormous amount of ground which cannot be called wholly unexplored, but which was at first only hurriedly run over in the search for placers (which are easily found), or where in later times only some of the more striking outcrops or quantities of float that could hardly be missed have received notice. Ten years, fifty years, a hundred years from now, people will be saying that the prospectors of 1892—and there are perhaps as many out at present as ever before—were merely skimming the ground and that they might almost as well have availed themselves of our aërial prospecting-car. It is not for lack of earnestness, nor altogether because there is insufficient knowledge of the art. The difficulty, if such it may be termed, is rather in the

magnitude of the field, which incites to superficial examination and distracts attention from closer work. An area ten miles square might be picked out in any number of favorable localities that would give an active prospector scope enough for a life work, even though he should not in any spot get much further than the surface.

THUS far we have had in mind as the ores to be prospected for only those supposably recognizable to the eye by men of ordinary experience; and these, as every miner knows, are but a part of the wide range of useful minerals. Of the precious-metal class, forming the main object of search, a large proportion of occurrences are obscure; while outside of that class and the usually associated minerals, besides coal, iron ore and a few other common substances, there is still greater uncertainty. The most skilful mineralogist is often at a loss to judge of the value of most ores on mere inspection, not of strange ores alone, but of that large class in which the valuable content is hidden in a mass of base material, giving little clue to the tenor of the metal sought for. Ores, as a rule, do not resemble cabinet specimens such as are provided for students in mineralogy to practice their skill in identification upon. In these the ore minerals are usually well crystalized and stand out distinctly from each other and the useless gangue, so that they often may be identified on sight. But with the bulk of ores, as they are found in nature and not in the museums, the different minerals are intimately mingled together and finely disseminated through the gangue, so that it is only by close scrutiny that the components can be detected in determinable condition; while the prospector has the added disadvantage of having to deal with them in their decomposed and weather-worn state. Hence the assayer is a safer guide than the mineralogist. The acute prospector, knowing that he cannot rely on his unaided eyesight and simple tests alone, will have assays made of whatever he thinks promising, if he can afford them. Yet, since the assayer is told to look only for certain things (usually gold and silver, or these and lead and copper), the examination thus made covers only the precious metals and their two most important associates. So that, after all, if complete knowledge of supposed ores is desired, the fire assay needs to be supplemented by other chemical and mineralogical tests.

AS between the scientific expert and the regular prospector in a competitive search for mineral, it would be pretty safe to bet on the latter every time. It is a pity that his acquaintance with mineralogy and geology is no greater than it is, for he certainly would be none the worse for a little more "book larnin'." But he has an instinct for finding ore which is not easily explainable and sometimes seems to be independent of both knowledge and the reasoning faculty; for his conclusions often rest, if you take his own word for it, upon some very queer notions. It may be that continued observation renders his mind suscepible to guiding influences and capable of a train of unconscious cerebration on lines which he himself does not realize. However that may be, it would appear that an experienced prospector, besides such practical qualifications as endurance of fatigue and familiarity with the diamond hitch, possesses other less evident traits of some sort that in part take the place of systematic training. Schools for miners in some of the Australasian colonies and elsewhere attempt to teach the elements of determinative mineralogy (of the useful minerals at least), and if our prospectors had the advantage of this instruction they would be all the better equipped for their work. Yet, if the functions of the prospector and the expert cannot be combined in one person, the one can be supplemented by the other. A prospecting party made up of three or four men, of whom one should have a technical training, might be the best expedient. The latter should be an assayer and at the same time, if not a professional mineralogist, competent to make determinations of minerals and having some idea of field geology. He should have a portable outfit for fire assay, a blowpipe kit, and some other testing appliances. He would remain in camp, oc-

cupied in assaying and otherwise testing the material brought in by the others; and they, having this resort at hand, need not be niggardly in taking specimens and samples of everything promising or unusual. A party thus organized ought to do good work.

This recalls a recent report that a party of explorers in Montana were to take the field with a novel prospecting outfit, comprising a portable electric core drill, light enough to be carried wherever a light wagon can be hauled, with a 5-horse-power boiler, engine, generator, tripod, diamond drills, wire, etc., the intention being to place the engine and boiler at a water source and transmit power thence to the points selected for drilling. The outfit, costing some $3000, is said to have a sinking capacity for 2000 feet. It is not stated what the objects of the party are, if any definite objective is in view. For coal, iron ore, silver-lead deposits in limestone, and indeed for underground prospecting in general, the diamond drill is a great thing. This is the first time that such an equipment has been taken into the field, away from a base, as far as known, and the result of the enterprise will be awaited with interest. It is a good idea, though beyond the means of most prospecting parties.

RECENT installations of complete electric plants for mines have turned attention more critically to the compressed-air system, which has been called by an electrician the only probable competitor of electricity in certain branches of mining work. The competition is likely to develop great improvements in both. The electric equipments of the Queen of the Hills, Virginius, Ute and Ulay, Gold King and other mines have been described at length in the technical press. The largest compressed-air plant in this country is at the Chapin iron mine, Michigan, where the power is generated at Quinnessee Falls and transmitted three miles. Wherever water-power is available within a reasonable distance it will obviously take the place of steam in most new equipments of any magnitude, if the managers are disposed toward economy. It is seldom that it can be applied directly in driving mining machinery, though there are a few mines, notably in California, where the Cornish pumps, and even the hoists, have been run by water-power, applied by turbines or impact wheels, and there are exceptional cases, as on the Comstock, where, by utilizing a deep drainage adit for discharge, the water can be taken down a shaft to run impact wheels within the mine itself, though there electrical transmission is resorted to. As a rule, water-power is in direct use only at the mills, which are then placed below and often at considerable distances from the mines. Since this source of power is generally more or less remote from the point of application at the mines, the energy has to be transmitted, and electricity has here great advantages over wire-rope transmission, which is inadmissable for this purpose except for short connections. Compressed air is not, with the exception of a very few examples like that of the Chapin mine just cited and some tunnel work, transmitted any great distance over the surface for mining, but is made at the shaft-house or tunnel mouth by compressors driven by steam and thence sent under ground in iron mains and rubber feed-pipes to run the drills, and less frequently pumps and "baby hoists" in winzes. Electricity can be transmitted several miles at a loss of only 20 per cent. and from that upward, depending on distance, voltage and size of conductor. The usual loss with compressed air, in ordinary use, is much larger. Professor Kennedy, in his report on the 25,000-horse-power compressed-air installation at Paris says that the system there is now being operated, on a large commercial scale, in such a fashion (admitting of considerable improvement) that a small motor four miles from the central station can indicate in round numbers 10 horse-power for 20 horse-power at the station itself. In this case, as in other installations in France, Germany and England, the air is reheated before used. Mr. William L. Saunders, in a lecture before the Franklin Institute (published in the Journal of the Institute for May, 1892), presented a masterly review of the present status and

possibilities of compressed air, in which he says—after admitting that the loss of power in common practice where compressed air is used to drive machinery in mines and tunnels is about 70 per cent. (where common compressors are used and the air is transmitted far enough to lose its heat of compression and is exhausted without reheating), and with the best compressors, but without reheating, about 60 per cent.—that these losses may be reduced as low as 20 per cent. by combining the best systems of reheating with the best compressors. Every one interested in mining machinery should read Mr. Saunders's analysis of the causes of this loss of power in air transmission, which are not mainly the friction and bends in pipe and leakages, as is commonly supposed, since after the air has traversed several thousand feet the pressure (by gage) at the delivery end is but little below that at the compressor, and reduction of the friction in the pipe depends upon providing a large enough cross-section area in proportion to the volume of air carried. It is chiefly a question of thermodynamics, the loss of power varying with the waste, during the long transit from compressor to machine, of the heat energy imparted in compressing the air; to which is added engine friction such as would result with any other system, and the mechanical losses in transmission mentioned. This view will surprise many, and is not altogether in accordance with the formulæ usually accepted for air friction in pipes; but Mr. Saunders gives proofs as well as cogent reasoning in support of his position. As air parts with its heat rapidly, covering the pipe would be ineffectual. The remedy, Mr. Saunders thinks, is to be found in reheating the air at or in the air-engine (that is, the drill, pump or other motor), for which a variety of methods are applicable at very low cost, by which an increase of efficiency is gained that is almost paradoxical. Whether this gain would not be more than offset by disadvantages arising from adding to the heat in mines and increasing the combustion products if coke, charcoal or "sestalit" is burned, is debatable. The electric resistance-coil for reheating the air would be least objectionable, though it would hardly pay to run a special wire for that purpose alone. There is no doubt that, for surface use, the reheating plan has great merits.

MINING use of any machine, appliance or system involves a new set of conditions and requirements beyond those which obtain in other applications. In some directions successful mining work hinges upon the minutest economies; in others there are considerations which outweigh cost of material or loss of power. In general, durability (or rather reliability) and adaptation to the special purpose in view are the prime essentials, and for machines working underground, where space and the choice of power are limited, light weight and compactness are very important. The question of saving in first cost and in running expenses must sometimes be waived. Fortunately, it often happens that efficiency and economy go together; or it may be that there is such a surplus of power available as to excuse theoretical wastefulness. Mines differ so much among themselves that for each particular case special study is required in selecting the equipment, and general statements have to be ventured with reservations. As to compressed air underground, it performs the very important secondary function of assisting ventilation; and in the case of the power drills the exhaust is delivered just where wanted, at the working face. In many mines, other than coal mines of the fiery kind, if compressed-air drills, pumps and winze hoists are used, blowers or fans may be dispensed with; and this consideration has often had much to do with their introduction. For drilling, compressed air is almost always more economical (as well as effective) than hand-labor; on the large scale of operations very much more, notwithstanding theoretical waste of power. Until lately it had a monopoly in driving percussion drills underground, though for open quarry work steam was also used. Now that the electric drills have been introduced, though as yet in but small number, competition is beginning. The electric percussion drills are not yet altogether satisfactory, but when a mine has been equipped with elec-

tric plant for operating its other machinery and for lighting, it is natural that the managers should wish to use electricity for all purposes to which power can be applied, and be willing to strain a point sometimes. Mr. Saunders, who stands up manfully for the compressed-air percussion drill (in which we agree with him, (for it has certainly been brought to a high pitch of development), believes that its advantages may be retained and the loss of power decreased by combining the electric engine with the air drill—that is, if electric power can be brought several miles and delivered underground at an efficiency of 80 per cent. then by putting in an electric engine to operate an air compressor as near the drills as possible, the latter could be run with but little thermodynamic loss. The compressors so arranged would take the mine air, or could be supplied by inlet ducts from the outside, which would give better ventilation. At first glance this looks like rather a roundabout way of solving the difficulty, but stranger things have been done. It might serve, pending further improvements in the electric drills (which, however, the makers are sanguine of effecting), in connection with other electric plant; but where steam is used for pumping and hoisting, the surface compressor and the usual supply-pipes have still a strong hold. The electric hoist underground is as simple an affair as the electric hoist at the shaft mouth; and the electric pump, though comparatively a new thing, is said to give satisfaction. Compressed air has been used to drive both of these machines, in mines where it was employed also for the drills, and with great convenience though not economically. Both it and electricity are far preferable to steam carried underground to pumps and winze hoists.

SELDOM do accidents in metal mines reach the proportions of the appalling disaster which occurred in the Birkenberg silver mine at Przibram, Bohemia, on the 1st of June, where, while a force of miners were below, a fire started which cut off the escape of four hundred men, who, unable to reach the shaft, perished miserably. When the timbering in a metal mine becomes ignited, sufficient time is usually allowed, if not for extinguishing the fire at its inception, at least for warning and saving the men underground; and often great damage to property is unaccompanied by loss of life. Disasters like that at Przibram are imminent only in mines of considerable extent of workings and containing masses of old timbering, and occur when fire starts at such a point and gathers such uncontrollable headway as to intercept those working beyond it.

The conspicuous gallantry of the rescuing parties in the Birkenberg mine furnishes one more illustration of the fortitude with which miners are ever ready to risk and lay down their lives for their endangered comrades. None can read the account without feeling a thrill of admiration. It is only when some such catastrophe as this makes a stir that people realize that heroism is not confined to battle-fields, shipwrecks and conflagrations of buildings. The mines are full of unaccredited heroes. The every-day risks of the occupation educe traits which in times of emergency are manifested in quiet, undemonstrative self-sacrifice. When fatality is averted, the incident passes unnoticed. But if an accident results in a tragedy, the telegraph and the printing-press bring it, for the moment, before the people, who while according generous praise look upon bravery as an attribute only to be expected of the miner, as it is a pre-assumed characteristic of the soldier, the sailor and the fireman.

ON the same day, June 5, two very serious disasters happened. During a flood rise of Oil creek, in the petroleum region of Pennsylvania, explosions of oil tanks and the burning of floating oil made a complication of terrors. Great damage to property at Oil City and Titusville was done, and many lives were lost. Simultaneously the greater part of the new silver mining camp of Creede, Col. (described and illustrated in the June number of this magazine) was being destroyed by fire, the loss being nearly $1,000,000, with but little insurance.

MACHINE-SHOP NOTES.

Conducted by Albert D. Pentz.

THE item of labor being that of greatest cost in ordinary manufacture, and it being the one that submits most readily to a substantial reduction by the use of modern mechanical equivalents for manual operations, it is obvious that manufacturers will find their interests better served by a devoted attention to their tool-plants than by a continual study of their power-plants exclusively. It is no uncommon occurrence to reduce the cost for labor in an operation by 25 per cent. solely by the use of machine-tools of improved design bought from the general market. I have known instances where 90 per cent. of the cost for the labor on hand operations was saved, where the part on which the operations were made was remodelled, special tools designed to do the work, and the operation put on piece-work; and I presume similar savings are noted in the experience of many other tool engineers. It is admitted, however, that it requires more work to design a new tool which may be relied on to effect a saving commensurate with its cost than to watch the coal-pile, and that the designing of tools necessitates some special practice and training. Still a few experiments with the more advanced modern tools such as can be bought in the general market will indicate in what lies the greater economy.

AN acquaintance of Düddler some months ago became interested in an invention and took the model and drawings to the latter's shop to get his opinion of it as an expert mechanic. Düddler thereupon spent half a day in confirming the general opinion that his acquaintance was quite sound financially. Then he looked the device over in company with his foreman and he persuaded that person that it was a good thing; or at least it would be good if it was to be made at Düddler's. That invention is still there, where four men at sixty cents an hour have been working at it until within a week or two. It is, however, now permanently laid aside as a failure. The acquaintance damns all inventors, pays his last bill and departs; Düddler, however, is complacent.

BLUNT, some years ago, found that his shop—then a smaller affair than it is to-day—had become stagnant. He was making money, feeling "good" and inclined to be generous to his employés. His men were satisfied, steady and loyal. They all worked along in the groove to which they were habituated and each produced about so much good work every day. One morning the mail brought the news that Keen, who made the engine that competed, had cut his prices so much that unless something was done to meet it Blunt's shop would have to close or lose money. That afternoon Blunt went to the city and carefully examined one of Keen's new engines and was both surprised and humiliated to find that it was a better machine than his own. It had a whole suit of new improvements, patented of course; it had new patterns throughout, the whole design harmonized well, making a symmetrical appearance, and it was warranted to be more efficient to an alarming degree. The only drop of comfort that Blunt could get out of this condition of affairs was that Keen was not quite ready to take orders for the immediate delivery of more than one size of engine. During the next month, one after another, there came six new draughtsmen into Blunt's office. Then his pattern-shop was filled with the best help he could find, and much work of this character was sent out to jobbing-shops. It took three years for Blunt to catch Keen, and it cost him a great deal of money; but it has taught him that no manufacturer can afford to go to sleep in prosperity.

THE engineer makes the machine but the manager makes the money. Management consists more in an infinite multitude of things adapted to take advantage of the circumstances of special occasions than in following any stated plan to its finish. Hence it is more a continual exercise of an alert good judgment than a methodical and cautious course of prudent consistency. Good managers, if they are enterprising, often make mistakes, for he who makes no mistakes makes nothing. but they have the faculty to transform defeat into victory, to change front and attack after a repulse, or to cover a retreat so that defeat is not annihilation; or, they are ready to follow up an advantage by another attack, to urge the manufacturing end or head so that smaller costs continually follow increased economy of production, and to drive the commercial end along so that greater profits accrue from increased sales at satisfactory prices. The manager can have but one grand object, and that is to conduct the business successfully; but he must have infinite resources.

IN packing machinery for sea voyages that are to extend over a long period of time, it is always to be feared that the iron and steel parts, especially if they are bright, will be damaged by rust due to the vapors arising from sea-water. White lead is often used to smear the bright parts with, but if the voyage is to be through torrid climates the lead in drying will become so solid and hard that it is removed with great difficulty if without injury to the surfaces. The cylinder oils and the greases that are prepared for smearing purposes from petroleum products sometimes fail to retain their hold on bright surfaces in a continued high temperature such as would be experienced in a voyage to Brazil, Chili, South Africa, or Australia, and such parts as become bare will rust. It is doubtful if anything which can be applied cold will retain its hold if it is not of such a character as to harden like a varnish or paint to the surfaces it covers, in a hot climate. Now because one fact of experience is worth a thousand theoretical conjectures it may be well to state how hundreds of thousands of fine machines have been sent to Australia, arriving there in perfect order as far as rust was concerned and without being smeared with anything farther than what is needed for the domestic trade. This method is entirely a matter of the box or case in which the machines are packed. The bottom, top, two sides, and two ends of the box are first formed as independent pieces, of kiln-dried pine lumber, and each one cleated so that they hold together as separate pieces, and the cleats are placed so that they reinforce the box when it is nailed together. In very heavy cases these cleats entirely surround these sides, etc., making a panel of each of them. When these elements are finished, so that they would make a neat box if they were nailed together, each is painted on the flat inner sides with a coating of hot rock asphaltum, which melts at about 214°. Then at once on to each of these coated surfaces is pressed a sheet of thick tough paper, which of course sticks firmly to the pitch. These sheets of paper are so shaped that their edges shall be held within the joints of the box when it is nailed together. Thus each of the two end sections will have paper turned over their four edges; each of the two side sections will have it turned over the two edges that receive the cover and bottom sections only; and the bottom and cover have the paper laid only on their flat sides and not turned over the edges at all. Then a second coat of the hot pitch is applied to all the exposed surfaces of the paper on all pieces except the cover. It is nailed together while hot and the joints are carefully payed with additional pitch. Into this case the goods are placed and protected with wrappings, then the cover is coated with the pitch and nailed on. This is the best form of "tar-lined" box. Cotton thread is often sent to sea in boxes lined with tin soldered tight; tea is always shipped from China in lead-lined chests and small parts of machines might be sent in such boxes as these; but in large cases this metal lining probably would be found too expensive.

THE cost of manufacture depends, in modern practice, inversely on the quantity

required to be made of any one thing within a given time. For instance, a complicated, knurled-headed and necessarily very accurately sized screw, perhaps two inches long and one inch in diameter, would cost $3 each for labor if made one at a time with the tools guided by hand in an engine-lathe, but if 50,000 of them were wanted in a year, an automatic screw-machine could make them for less than two cents each for labor alone.

THE same quality of foresight which provides materials for next month's work should lead manufacturers to provide skilled mechanics for the next generation of workmen. If boys in machine-shops had not in the past been a paying kind of labor it is extremely doubtful where or how machinists would have been instructed in that which they are expected to know. At present there are rather more skilled workmen than there is employment for, owing to the rapidly-increasing use of self-guiding tools that require no mechanical skill to use them and which may as well be operated by one person as by another after a few hours of instruction. But these men who now are in abundance will grow old, and the trades unions are limiting the number of apprentices. Hence, unless there is other provision now made for the education of their successors there will in time be a scarcity of good men and an era of high wages that will be very gratifying to such men as then may have a sound practical training.

EXPERIMENTS made several years ago convinced me that both ends of a milling-machine spindle could be used advantageously, and two operations could be done on it together, thus effecting a saving. While one cut was being operated on a piece in a fixture on one end of the machine, the piece that had been cut on the other end could be removed and another could be inserted. The chief difficulty in thus running a spindle continuously while work is being returned under a moving cutter is that the previous cut will be marred and the cutter itself will be injured. If, however, each slide can be arranged so that it will drop when it is moved backward, and rise, when it is fed forward, like the four-motion feed of a sewing-machine, this objection will be overcome. The mechanisms to do this in a number of ways have been designed for other things, and it strikes me that this modification could be effected easily by any good mechanic.

AFTER engineers have become tired of all kinds of complicated and expensive bearings for machine-spindles they will all come to the conclusion that the cylindrical bearing is best if it be housed within a split journal box. Furthermore in most cases they will prefer a cast-iron journal. When, however, they prefer something better, it will be a bushing within this split journal box of hardened steel flanged on one end to meet the greater thrust. This hardened bushing will doubtless be split at the point diametrically opposite the split in the housing of cast iron.

A REAL-ESTATE lawyer and a mechanical engineer both do business in New York City and they are neighbors and acquaintances in the country. The lawyer not long ago had made a blue-print frame to copy maps and other tracings that come into his temporary possession. He had difficulty in getting clear lines, and on the train one morning he stated his trouble to the engineer who explained the necessity of a close contact of the tracing to the sensitized paper over the whole surface. Presuming on this assistance, the engineer a month afterward asked the lawyer a legal question relating to a leasehold. The legal man could not answer on board the train and invited the engineer to his office, where the desired information was given in ten minutes. On the first of the next month the lawyer sent in his bill for the advice. Then the engineer sent in a bill for a similar sum for his advice. The lawyer says it is "ridiculous—friendly talk on the train—don't remember much about it, but never heard of a bill for a little simple thing of that kind." Now why is it ridiculous for a mechanic to charge reasonably for professional advice?

CURRENT TECHNICAL LITERATURE.

TO THE READER.—This catalogue is compiled from the technical periodicals of the United States, England and France. If you were to subscribe only for those of most importance, it would cost you over $500.00 a year. If you were to undertake to read them, you would do nothing else from year's end to year's end. To subscribe for THE ENGINEERING MAGAZINE and get the benefit of this catalogue costs you but $3 a year. To glance over those departments of the catalogue in which you are chiefly interested, and decide which of the articles listed are of real value to you, requires but fifteen minutes of your time each month. If you have taken the precaution to purchase a stock of our coupons, it will take you but ten minutes more to fill out, say a dozen, and enclose them in an envelope to THE ENGINEERING MAGAZINE COMPANY, WORLD BUILDING, NEW YORK. No letter-writing is required. A stamped envelope does the work. In return you will receive the dozen articles desired, though they may be published at a dozen different points in the world.

The articles should be ordered *by number*, not by title alone. The prices are 15, 30, and 45 cents. Articles at 30 cents are indicated by an asterisk (*), those at 45 cents by a dagger (†). Coupons, with blanks for the number of the article and the purchaser's address, are furnished at 15 cents each, or $1 for 7, $5 for 35, and $12.50 for 100. Each coupon is receivable in exchange for a 15-cent article. Two coupons must be sent for a 30-cent article, and three for a 45-cent article. All orders *must* be accompanied by cash or coupons. English and French patrons will confer a favor by remitting English or French postage stamps of small denominations.

THE AMERICAN PRESS.

A An.... American Analyst. *f.* $1 per year. N. Y.
AA..... American Architect. *w.* $6. Boston.
A Af..... American Artisan. *w.* $2. Chicago.
A C J.... Am. Chemical Journal. *b-m.* $4. Baltimore.
A D.... American Druggist. *m.* $1.50. New York.
A G L J.. Am. Gas Light Journal. *w.* $3. New York.
A G..... Am. Geologist. *m.* $3.50. Minneapolis.
A J Phar. Am. Journal of Pharmacy. *m.* $3. Phila.
A J P.... American Journal of Photography. *m.* $2 per year. Philadelphia.
A J R A.. American Journal of Railway Appliances. *m.* $2 per year. New York.
A M..... American Machinist. *w.* $3. New York.
A M & I W. American Manufacturer and Iron World. *w.* $4 per year. Pittsburg.
A A A.... Annals of Am. Academy of Political and Social Science. *b-m.* $6. Philadelphia.
A H..... Annals of Hygiene. *m.* $2 per year. Phila.
A P B.... Anthony's Photographic Bulletin. *s-m.* $3 per year. New York.
A R..... Architectural Record. *q.* $1. New York.
A Rev.... Architectural Review. *s-q.* $5. Boston.
A & B.... Architecture and Building. *w.* $6 N. Y.
A..... Arena. *m.* $5 per year. Boston.
A & N J.. Army and Navy Journal. *w.* $6. New York.
A & N R.. Army and Navy Register. *w.* $3 per year. Washington.
At M..... Atlantic Monthly. *m.* $4 per year. Boston.
B J C.... Boston Journal of Commerce. *w.* $3 per year. Boston.
B & W... Builder and Woodworker. *m.* $1. N. Y.
B P..... Bulletin of Pharmacy. *m.* $1. Detroit.
C A..... Calif. Architect. *m.* $3. San Francisco.
C E N.... Canadian Electrical News. *m.* $1 per year. Toronto.
C & B... Carpentry and Building. *m.* $1. New York.
C M..... Century Magazine. *m.* $4 per year. N. Y.
Ch..... Chautauquan. *m.* $2. Meadville, Pa.
C E..... Colliery Engineer. *m.* $2. Scranton, Pa.
C..... Compass. *m.* $2 per year. New York.
Cos..... Cosmopolitan. *m.* $3 per year. New York.
Cr..... Crank. *m.* $1.25 per year. Ithaca, N. Y.
D E..... Domestic Engineering. *m.* $1. Chicago.
D J..... Drainage Journal. *m.* $1. Indianapolis.
D Jour.. Druggists' Journal. *m.* $1. Chicago.
E A..... Electrical Age. *w.* $3 per year. New York.
E E N Y.. Electrical Engineer. *w.* $3 per year. N. Y.
E R N Y.. Electrical Review. *w.* $3 per year. N. Y.
E W..... Electrical World. *w.* $3 per year. N. Y.
E & R... Electricity and Railroading. *m.* $1 per year. Boston.
Eng..... Engineer. *s-m.* $2 per year. New York.
E M J.... Engineering and Mining Journal. *w.* $4 per year. New York.
E Mag... Engineering Magazine. *m.* $3. New York.
E M..... Engineering Mechanics. *m.* $2. Phila.
E N..... Engineering News. *w.* $5 per year. N. Y.
F & M R.. Financial and Mining Record. *w.* $3. N.Y.
F W..... Fire and Water. *w.* $3 per year. N. Y.
F..... Forum. *m.* $5 per year. New York.
G & F.... Garden and Forest. *w.* $4 per year. N.Y.
G G M... Goldthwaite's Geographical Magazine. *m.* $2 per year. N. Y.
G R..... Good Roads. *m.* $2 per year. N. Y.
I A..... Inland Architect. *m.* $5 per year. Chicago.
I R W... India Rubber World. *m.* $3 per year. N.Y.
I S F.... Industry. *m.* $2 per year. San Francisco.
I Age.... Inventive Age. *s-m.* $1. Washington.
I T R.... Iron Trade Review. *w.* $3. Cleveland.
J A C S.. Journal of the American Chemical Society. *m.* $5 per year. N. Y.
J A E S.. Journal of the Association of Engineering Societies. *m.* $3 per year. Chicago.
J F I..... Journal of the Franklin Institute. *m.* $5 per year. Philadelphia.
J M S I.. Journal of the Military Service Institution. *b-m.* $4 per year. Governor's Island, N. Y. H.
J N E W. Journal of the N. E. Waterworks Association. *q.* $2. New London, Conn.
L M..... Leather Manufacturer. *m.* $3. N. Y.
L E..... Locomotive Engineering. *m.* $2. N. Y.
M & B... Manufacturer and Builder. *m.* $1.50. N. Y.
M R..... Manufacturer's Record. *w.* $4. Baltimore.
M N..... Mechanical News. *s-m.* $1.50. New York.
M & El... Mechanic and Electrician. *w.* $2 per year. St. Louis.
Met W.... Metal Worker. *w.* $2 per year. N. Y.
Min..... Minerals. *m.* $1 per year. N. Y.
M S P.... Mining and Scientific Press. *w.* $3 per year. San Francisco, Cal.
M S R.... Mining and Scientific Review. *w.* $2 per year. Denver.
M I T.... Mining Industry and Tradesman. *w.* $3 per year. Denver.
Misc..... Miscellaneous.
N B..... National Builder. *m.* $3. Chicago.
N C B... National Car Builder. *m.* $2. N. Y.
N A R... North American Review. *m.* $5. N. Y.
N W..... Northwestern Architect. *m.* $3. Minneapolis.
O M..... Overland Monthly. *m.* $3 per year. San Francisco.
P L..... Pacific Lumberman, Contractor, and Electrician. *w.* $3. San Francisco.
P..... Paving and Municipal Engineering. *m.* $1 per year. Indianapolis.
P Era... Pharmaceutical Era. *s-m.* $2. Detroit.
P R..... Pharmaceutical Record. *s-m.* $1.50. N. Y.
P T..... Photographic Times. *w.* $5 per year. N. Y.
P S N... Popular Science News. *m.* $1. Boston.
P S..... Power-Steam. *m.* $1 per year. N. Y.
P E..... Practical Electricity. *f.* $2 per year. Boston.
P A..... Progressive Age. *w.* $3. New York.
R A E J.. Railroad and Engineering Journal. *m.* $3 per year. New York.
R C J.... Railroad Car Journal. *m.* $1 per year. N.Y.
R G..... Railroad Gazette. *w.* $4.20 per year. N. Y.
R A..... Railway Age. *w.* $4 per year. Chicago.
R M M.. Railway Master Mechanic. *m.* $1. Chicago.

R R.....Railway Review. *w.* $4 per year. Chicago.
R P.....Registered Pharmacist. *w.* $1. Chicago.
R & T...Roofer and Tinner. *m.* $1 per year, N. Y.
S V.....Safety Valve. *m.* $1 per year. N. Y.
S L P....Saint Louis Photographer. *m.* $3. St. Louis.
San.....Sanitarian. *m.* $4 per year. Brooklyn.
S Era .. Sanitary Era. *m.* $1 per year. N. Y.
S P.....Sanitary Plumber. *s-m.* $1. N. Y.
S M Q.. .School of Mines Quarterly. $2. N. Y.
Sc.....Science. *w.* $3.50 per year. New York.
Sea.....Seaboard. *w.* $2 per year. N. Y.
S A.....Southern Architect. *m.* $1. Atlanta.
S E.....Stationary Engineer. *w.* $2. Chicago.
S.....Stone. *m.* $2 per year. Indianapolis, Ind.
S R G....Street Railway Gazette. *w.* $5. Chicago.
S R N. ..Street Railway News. *w.* $3. N. Y.
T Q.....Technology Quarterly. $2. Boston.
T A I E E.Transactions American Institute of Electrical Engineers. *m.* $5 per year. N. Y.
W E.....Western Electrician. *w.* $3. Chicago.
W P M...Wilson's Photographic Magazine. *s-m.* $5 per year. N. Y.

THE FOREIGN PRESS.

B J P....British Journal of Photography. *w.* 10*s.* 10*d.* per year, post-paid. London.
C T J....Chemical Trade Journal. *w.* 12*s.* 6*d.* per year, post-paid. Manchester, Eng.
C G.... ..Colliery Guardian. *w.* 27*s.* 6*d.* per year, post-paid. London.
C R.....Contemporary Review. *m.* $4.50 per year, New York. London.
E E L....Electrical Engineer. *w.* 17*s.* 4*d.* per year. post-paid. London.
E P .....Electrical Plant. *m.* 6*s.* per year, post-paid. London.
E R L ....Electrical Review. *w.* 21*s.* 8*d.* per year, post-paid. London.
El.. .....Electrician. *w.* 24*s.* post-paid. London.
El P.....Electricien. *w.* 25 *fr.* post-paid. Paris.
E L.....Electricity. *w.* 6*s.* 6*d.*, post-paid. London.
Eng L... Engineer. *w.* 36*s.*, post-paid. London.
E.....Engineering. *w.* 36*s.*, post-paid. London.
F R.....Fortnightly Review. *m.* $4.50 per year. New York. London.
G E M...Gas Engineers' Magazine. *m.* 6*s.* 6*d.* per year, post-paid. Birmingham, Eng.
G W.....Gas World. *w.* 13*s.*, post-paid. London.
G C.....Génie Civil. *w.* 45 *fr.*, post-paid. Paris.
I C B.....Illustrated Carpenter and Builder. *w.* 8*s.* 8*d.* per year, post-paid. London.
I E.....Indian Engineering. *w.* Rs. 18 per year, postage extra. Calcutta.
I L. .....Industries. *w.* 32*s.*, post-paid. London.
Inv .. ..Invention. *w.* 28*s.*, post-paid. London.
I.....Iron. *w.* 30*s.* per year, post-paid. London.
J G L....Journal of Gas Lighting. London.
K.....Knowledge. *m.* 6*s.*, post-paid. London.
M . ....Machinery. *m.* 9*s.*, post-paid. London.
M E .....Marine Engineer. *m.* 7*s.* 6*d.* per year, post-paid. London.
M W.....Mechanical World. *w.* 8*s.* 8*d.* per year, post-paid. London.
M P.....Moniteur de la Photographie. *b-m.* 18 *fr.* per year, post-paid. Paris.
M I.....Moniteur Industriel. 3 times a week. 40 *fr.* per year, post-paid. Paris.
N C.....Nineteenth Century. *m.* $4.50 per year. New York. London.
P Eng...Practical Engineer. *w.* 12*s.* 6*d.* per year. post-paid. London.
R N.....Railway News. London.
R U M...Revue Universelle des Mines. *m.* 40 *fr.* per year, post-paid. Paris.
S R.....Sanitary Record. *m.* London.
W R.....Westminster Review. *m.* $4.50 per year. N. Y. London.

ARCHITECTURE.

*3378. Great English Architects. I. Early Masters (I C B-April 1.) 2600 w.

3380. Theatre Building Regulations. I. (A A-April 16.) 2000 w.

3381. The Chicago Construction, or Tall Buildings on a Compressible Soil. Ill. W. L. B. Jenney (Ibid.) 1800 w.

3382. Amended Building Law for the City of New York. (A & B-April 16.) 29,000 w.

†3509. Origin of the Cruciform Plan of the Mediæval Cathedral. Ill. Edmund M. Wheelwright (A Rev- March 14.) 4500 w.

3568. On the Older Forms of Terra-Cotta Roofing-Tiles. IV. Ill. (A A-April 23.) 5500 w.

3576. Saracenic Architecture. IV. Prof. Aitchison (A & B-April 23.) 4000 w.

3577. The Architect and the Crafts. J. J. Burnet (Ibid.) 1600 w.

3578. Architects' License Law, New York. (Ibid.) 1300 w.

*3631. Great English Architects. Inigo Jones. II (I C B-April 15.) 1800 w.

*3632. Structural Ironwork. (Ibid.) 1600 w.

†3679. Gen. William Sooy Smith's Paper on High Buildings Criticised. P. B. Wight (I A-April.) 3000 w.

†3680. Proposed Technological School from the Standpoint of the Architect. Dankmar Adler (Ibid.) 1750 w.

†3681. The Decorative Uses of Sculpture. E. Roscoe Mullins (Ibid.) 1400 w.

†3732. Homesteads of the Blue-Grass. Ill. James Lane Allen (C M-May.) 6200 w.

†3733. Architecture at the World's Columbian Exposition. Ill. Henry Van Brunt (Ibid.) 10,000 w.

*3751. Choice in Architectural Styles. Edward A. Freeman (A R-Apr-June.) 4200 w.

*3752. Architectural Aberrations. The Brooklyn Real Estate Exchange. Ill. (Ibid.) 1400 w.

*3753. The Battle of the Styles. II. A. D. F. Hamlin (Ibid.) 3500 w.

*3754. The Chicago Auditorium. Ill. Dankmar Adler (Ibid) 6500 w.

*3755. A Modern Cathedral. II. R. W. Gibson (Ibid.) 5000 w.

*3756. Iron Construction in New York City. Past and Future. Ill. Louis De Coppet Berg (Ibid.) 4400 w.

*3757. The Vicissitudes of Architecture. I. Leopold Eidlitz (Ibid.) 3600 w.

*3758. Byzantine Architecture. Neo-Byzantine. IV. Prof. Aitchison (Ibid.) 2700 w.

3776. Byzantine Art. Ill. H. Mayeux (A A-April 30.) 1500 w.

3777. Scales and Imbrications. I. Ill. L. Passepont (Ibid.) 2200 w.

3781. Buildings in Sweden. (M N-May 1.) 900 w.

3812. Contracts and Conditions. W. H. Sayward (C & B-May.) 2300 w.

3813. An Independent Ceiling. Ill. A. D. Pentz (Ibid.) 1400 w.

3841. Saracenic Architecture. Ill. V. Prof. Aitchison (A & B-April 30.) 4200 w.

3842. Some Recent Developments in Theatre Planning. E. A. E. Woodrow (Ibid.) 5200 w.

†3916. Tradition in Church Architecture. Ill. Barr Ferree (A & B-May 7) 2900 w.

†3917. The Heating and Ventilation of Churches. F. E. Kidder (Ibid.) 2100 w.

†3918. Suggestions as to Church Seating. Ill. Owen B. Maginnis (Ibid.) 1000 w.

*3979. History of Mortars and Cements. Adolph Cluss (S-May.) 1500 w.

4002. Byzantine Architecture. Ill. I. Edward Corroyer (A A-May 7.) 1900 w.

4003. Construction. Ill. VI. M. Viollet-le-Duc (Ibid.) 4200 w.

4004. Theatre Building Regulations. II. E. A. E. Woodrow (Ibid.) 2200 w.

4024. The Architectural Exhibition in Brooklyn. Barr Ferree (Sc–May 6.) 950 w.

*4026. Paris Under the III Eyed Napoleon as Seen by the Student. W. L. B. Jenney (Misc.) 3600 w.

*4027. The Stone Age. J. Gash (Misc.) 1900 w.

*4088. Architect or Engineer? Editorial (N B–May.) 900 w.

4098. Byzantine Architecture. Ill. II. Edward Corroyer (A A–May 14.) 1800 w.

4099. Scales and Imbrications. II. Ill. L. Passepont (Ibid.) 1400 w.

4100. Theatre Building Regulations. III. E. A. E. Woodrow (Ibid.) 2800 w.

4107. Saracenic Architecture. VI. Prof. Aitchison (A & B–May 14.) 2700 w.

4108. Wrought Iron Work—The Renaissance Period. Starkie Gardner (Ibid.) 1900 w.

4266. A Snort History of English Renaissance Architecture. I. Charles T. Mathews (A & B–May 21.) 3000 w.

4267. On the Evidence of Scientific Knowledge in the Remains of Ancient Architecture and Engineering. I. T. Claxton Fidler (Ibid.) 3600 w.

4268. The Decorative Features of Sculpture. E. Roscoe Mullins (Ibid.) 5200 w.

4282. Fireplaces. Ill. I. G. Aubry. (A A–May 21.) 1750 w.

4283. Construction. VII. Ill. M. Viollet-le-Duc (Ibid.) 5500 w.

†4385. Les Constructions Urbaines aux Etats-Unis. Ill. A. Stévart (R U M–April.) 6000 w.

†4418. The Building Problem in Chicago from an Engineering Standpoint. Ill. Wm. Sooy Smith (Misc.) 5100 w.

†4423. Terra Cotta: Its Properties and Architectural Uses. C. J. Butterfield (Misc.) 1100 w.

†4425. Japanese Temple Architecture. Shigetsura Shiga (Misc.) 2900 w.

†4432. Classification of Architectural Illustrations. James M. White (Misc.) 2000 w.

4440. A Short History of English Renaissance Architecture. II. Charles T. Mathews (A & B–May 28.) 1600 w.

4441. Saracenic Architecture. VII. Prof. Aitchison (Ibid.) 2400 w.

4442. On the Evidence of Scientific Knowledge in the Remains of Ancient Architecture and Engineering. II. Ill. T. Claxton Fidler (Ibid.) 800 w.

4451. Fireplaces. Ill. II. G. Aubry (A A–May 28.) 950 w.

†4461. Some Notes Upon the Earlier Chicago Architects. I. Dankmar Adler (I A–May.) 2000 w.

4462. How Theatres Should be Constructed. C. J. Hexamer (F W–May 28.) 1200 w.

4634. Concrete: Its Composition and Uses. I. (C & B–June.) 1600 w.

4635. The House that Jonathan Builds. Horace Townsend (Ibid.) 3500 w.

4640. Saracenic Architecture. VIII. Prof. Aitchison (A & B–June 4.) 2600 w.

4641. A Short History of German Renaissance Architecture. Charles T. Mathews (Ibid.) 2400 w.

4642. Canadian Architecture. Mr. Langton (Ibid.) 1800 w.

4643. Pastels in the Studio of the Architect. W. Howard Seth-Smith (Ibid.) 3000 w.

4645. Fireplaces. Ill. III. G. Aubry (A A–June 4.) 1100 w.

4646. Construction. Ill. VIII. M. Viollet-le Duc (Ibid.) 2200 w.

4689. An Architectural Scholarship for Philadelphia. Barr Ferree (Sc–June 3.) 1000 w.

4728. Polytechnic Schools and Architecture. Editorial (N B–June.) 900 w.

4768. History of Spanish Renaissance Architecture. Ill. Charles T. Mathews (A & B–June 11.) 2400 w.

4770. Saracenic Architecture. IX. Prof. Aitchison (Ibid.) 2500 w.

*4788. The Decorative Features of Sculpture. I. (Misc.) 2900 w.

4793. Roofing. I. Ill. A. Rospide (A A–June 11.) 2400 w.

4794. Construction. IX. Ill. M. Viollet-le-Duc (Ibid.) 4000 w.

4796. The First M. E. Church and Its Associated Buildings, Baltimore. Ill. A. A. Cox (Ibid.) 3100 w.

*4834. Mud, a Material in Persian and Eastern Architecture. Ill. William Simpson (Misc.) 12,000 w.

*4847. The Greatest of All Fair Buildings. Ill. Joseph Kendall Freitag (E Mag–July.) 3000 w.

CIVIL ENGINEERING.

*3369. The Future "World's Highway." III. T. Graham Gribble (E Mag–June.) 3000 w.

*3372. Ropes Pass, Texas. Ill. Wm. Kent (Ibid.) 3000 w.

*3377. Impending Disaster on the Mississippi. A Southern Engineer (Ibid.) 3000 w.

3403. The Improvement of Southern Harbors. III. Ill. Lewis M. Haupt (M R–April 15.) 2100 w.

3404. The Nicaragua Canal. II. C. E. Dutton (Ibid.) 2800 w.

3413. London Bridges Across the Thames. Ill. (R R–April 16.) 1000 w.

3439. The Roads of Pennsylvania. Ill. F. F. Weld (P–April.) 1900 w.

3431. Eastern Views on Western Paving (Ibid.) 100 w.

*3432. Buoying and Lighting Tidal Rivers. I. Ill. W. H. Wheeler (Eng L–April 8.) 3600 w.

*3479. The Use of Basic Steel in Bridge Construction. H. F. Kintzlé (I–April 8.) 3300 w.

3484. What a Wagon Road Ought to Be. G. M. Ford (E M J–April 16.) 1250 w.

3507. An End-Adjusting Gear for Draw-Bridges. Ill. C. A. R. Turner and P. A. Warner (E N–April 16.) 1000 w.

*3519. Bengal Canals. I. Editorial (I E–March 19.) 1100 w.

*3521. The Godaven Bridge at Rajahmundry, East Coast Railway. Note by the Consulting Engineer to the Government of India for State Railways (Ibid.) 1200 w.

*3522. Discharges of the River Indus. Ill. R. B. Joyner (Ibid.) 2500 w.

*3531. The Civil Engineer. Conrad Haney (J A E S–Feb.) 2300 w.

*3532. Bridge Legislation. Horace E. Horton (Ibid.) 5000 w.

*3535. The Behavior of Iron Columns at High Temperatures. A. Gottlief (Ibid.) 6000 w.

*3536. Some Trials and Responsibilities of the Engineer. E. H. Wilson (Ibid.) 1100 w.

3565. The Strength of Struts. Ill. M. McCabe (R G–April 22.) 1600 w.

3569. The Improvement of Southern Harbors. IV. Lewis M. Haupt (M R–April 22.) 900 w.

3570. The Improvement of Charleston Harbor. Frederic V. Abbot and Lewis M. Haupt (Ibid.) 2700 w.

3584. The Construction and Maintenance of Highways. Eugene L. Mundin (E M J–April 23.) 2400 w.

3585. Good Roads. Lawrence E. Baker (Ibid.) 1100 w.

*3592. Restauration du Pont-Canal de la Teyssonne. Ill. Mazoyer (G C–April 9.) 2200 w.

3685. A New Process for Dealing with Quicksand. Ill. (E N–April 28.) 2600 w.

3687. Lowering Submerged Water Pipe Across the Platte River at Denver, Colo. Ill. C. P. Allen (Ibid.) 600 w.

*3709. The Severn Tunnel. Ill. Chas. Richardson (J G L–April 19.) 10,500 w.

3712. Improvement of Our Country's Highways. Wm. H. Smeaton (E M J–April 30.) 850 w.

3717. The Improvement of Southern Harbors. V. Lewis M. Haupt (M R–April 29.) 1800 w.

3718. The Jetties at Charleston Harbor. A. W. Swanitz (Ibid.) 700 w.

3719. The Nicaragua Ship-Canal. Ill. J. Jay Williams (Ibid.) 1850 w.

*3734. Bengal Canals. II. Editorial (I E–March 26.) 1300 w.

*3735. Irrigation in the Panjab. I. (Ibid.) 1800 w.

†3741. Public Streets and Highways. Ill. George N. Bell (San–May.) 3800 w.

3891. The Improvement of Southern Harbors. Ill. VI. Lewis M. Haupt (M R–May 6.) 1500 w.

†3968. Flood Discharge from Small Watersheds. Ill. Dwight Porter (T Q–Dec.) 4500 w.

*3978. A Gospel of Good Roads (S–May.) 2000 w.

*3995. The Tansa Dam. Ill. (E–April 29.) 1800 w.

*3997. Concrete in Harbor Works. Editorial (Ibid.) 700 w.

4047. (*Price of this article: $2, or 14 coupons.*) Some Disputed Points in Railway Bridge Designing. Ill. J. A. L. Waddell, T. H. Johnson, T. C. Clarke, G. F. Swain, J. M. Johnson, Carl Gayler, G. Lindenthal, Wm H. Burr, L. L. Buck, J. B. Johnson, Henry T. Eddy, Edwin Thacher, C. L. Gates, C. S. Churchill, Robert Moore, Mansfield Merriman, A. J. Du Bois, J. P. Snow, W. R. Hutton, W. L. Cowles, Paul L. Wölfel, P. C. Ricketts, G. Bouscaren, H. M. Filley, J. Sterling Deans, F. H. Smith, H. H. Quimby, John A. Fulton, Benjamin Douglas, S. T. Wagner, Wm. Cain, F. C. Osborn, W. H. Breithaupt, F. W. Skinner, A. J. Swift, O. F. Nichols, Henry B. Seaman, Ward Baldwin, J. C. Bland, A. C. Stites, Lee Treadwell, G. M. Blakeley, and Henry W. Hodge. Ill. (Misc.) 110,000 w.

†4052. Railway Reconnoissance and Preliminary Survey in the Rocky Mountains. W. H. Lawson (Misc.) 2100 w.

†4055. The Proportions of Canals and Ditches. Ill. John S. Titcomb (Misc.) 3300 w.

†4056. The Gauging of Our Streams. L. R. Hope and John S. Titcomb (Misc.) 4100 w.

†4059. Utilization of the Underflow of Streams for Irrigation. E. L. Rogers and W. W. Follett (Misc.) 1400 w.

†4061. Earthen *vs.* Masonry Dams. W. W. Follett (Misc.) 6700 w.

†4062. Irrigation on the Maxwell Grant, New Mexico. Ill. L. S. Preston (Misc.) 3800 w.

*4068. A Perfect Railway Curve. Ill. D. E. Hughes (I S F–May.) 2700 w.

*4070. A Topographical Survey of California. Willard D. Johnson (Ibid.) 1900 w.

4078. Street Pavements in Boston and Other Cities. (E N–May 12.) 2400 w.

*4115. Irrigation in the Panjab. II. Ill. (E–April 9.) 1150 w.

4131. Gravel Roads. Geo. B. Fleece (P–May.) 2700 w.

4132. "Overflow Asphalt" Pavements Condemned in Denver. (Ibid.) 1400 w.

4145. The Floor System of Bridges. Ill. (R A–May 13.) 800 w.

*4160. Allowable Load on Piles. R. Haagsma (E–May 6.) 1700 w.

*4161. Masonry Bridges with Semi-Free Joints. Ill. (Ibid.) 4600 w.

4168. The Memphis Bridge Over the Mississippi River. Ill. (R R–May 14.) 2400 w.

*4178. Adjustable Lock and Weir. Ill. Sphincter Grip Armored Hose Company (Eng L–May 6.) 1500 w.

*4188. The Kistna Bridge, East Coast Railway. (I E–April 16.) 2600 w.

*4226. The Roads of Ohio. Ill. J. M. H. Frederick (G R–May.) 2700 w.

*4227. Good Roads. Ill. William A. Miller (Ibid.) 2100 w.

*4228. The Roads and Streets of Trinidad (British West Indies). Ill. Mr. Devenish (Ibid.) 3800 w.

4249. Dry Dock for the U. S. Naval Station at Puget Sound, Washington. Ill. (E N–May 19.) 1900 w.

4256. A New Type of Dam. Latham Anderson (Ibid.) 600 w.

4261. The River and Harbor Bill. Lewis M. Haupt (M R–May 20.) 1500 w.

4262. The Construction and Maintenance of Dirt Roads. F. M. Pennock (Ibid.) 1400 w.

4274. Disputed Points in Railroad Bridge Designing. Editorial (R G–May 20.) 2000 w.

*4320. Wainfleet Haven Improvement. Ill. (Eng L–May 13.) 1000 w.

*4324 Progress of the Manchester Ship Canal. Ill. (Ibid.) 1900 w.

*4397. Country Road Building. "A Crank" (Misc.) 1250 w.

4399. The Harlem River Bridge at 155th Street, New York. Ill. (E N–May 26.) 1400 w.

4402. A Convenient Wheel-Base Moment Diagram. (Ibid.) 600 w.

4410. Erecting the Kentucky River Bridge at Irvine, Ky. Ill. John H. Pearson (Ibid.) 1800 w.

†4419. Field Riveting. Z. Foster (Misc.) 1300 w.

†4420. Foundations for Bridges. P. Morgensen (Misc.) 1800 w.

†4421. Precise Levels of the Mississippi River Commission. R. J. Dickinson (Misc.) 650 w.

†4422. River Gauging. Horace Dunaway (Misc.) 2200 w.

†4426. Manufacture of Paving Brick. F. M. Spalding (Misc.) 1400 w.

†4429. Notes on the Compressive Resistance of Brick. Ira O. Baker (Misc.) 600 w.

*4465. Underpinning by Means of Grouting and Stock-Ramming. I. Ill. Walter Robert Kinipple (E–May 20.) 2800 w.

*4468. The Woodside Lairage, Birkenhead. Ill. (Ibid.) 3100 w.

*4493. Wood and Asphalt Paving. Editorial (Eng L–May 20.) 1700 w.

4562. Topographical Survey of the State of New York. W. P. Trowbridge (S M Q–April.) 4300 w.

†4579. Brick Manufacture and Brick Pavement. Ill. F. A. Calkins, Calvin Tompkins, S. Whinery, T. C. Clarke, S. C. Thompson, A. F. Sears, R. H. Thurston, William Steyh, L. Kingman, H. M. Marshall, William C. Jewett, S. S. Haight, A. N. Talbot, and G. W. Rafter (Misc.) 29,000 w.

4608. The Chicago Drainage Canal. Ill. (E N–June 2.) 1900 w.

4610. Concrete Plant at the Cascades Canal, Oregon. Ill. (Ibid.) 1500 w.

4616. Roads in Bohemia. J. B. Hawes (Ibid.) 1800 w.

4622. The Foundations of the Seventh Avenue Bridge, New York. Daniel E. Moran (R G–June 3.) 1500 w.

*4636. Bengal Canals. III. (I E–April 30.) 1000 w.

*4649. Underpinning by Means of Grouting and Stock-Ramming. II. Ill. Walter Robert Kinipple (E–May 27.) 2600 w.

*4662. San Diego Harbor. Ill. Otto Von Geldern (I S F–June.) 2000 w.

*4747. Principauté de Monaco. Fermeture de la Rade au Moyen d'un Brise-lames Flottant. Ill. J. Favrel (G C–May 28.) 600 w.

4748. The Big Bull Tunnel, Clinch Valley Division Norfolk & Western Railroad. Ill. Emile Low (E N–June 9.) 4400 w.

4751. The Bridge over the Cerveyrette Gorge, France. Ill. (Ibid.) 400 w.

4753. "Stress" and "Strain." John C. Trautwine Jr. (Ibid.) 1300 w.

4760. Lift Bridge Over the Harlem River. Ill. (R G–June 10.) 900 w.

*4782. Asphalt and Its Uses. Ill. Francis V. Greene (G R–June.) 4500 w.

*4783. Streets and Roads of Washington. Ill. Frank L. Dyer (Ibid.) 4500 w.

*4841. Convict Labor in Road-Making. Albert Roberts (E Mag–July.) 3000 w.

*4842. Engineering off Cape Hatteras. Ill. J. W. Walters (Ibid.) 3000 w.

ELECTRICITY.

*3384. La Locomotive Electrique de MM. H. Bonneau et E. Desrozlers. Ill. Max de Nansouty (G C–April 2.) 6400 w.

*3398. Mérite Relatif de Différents Métaux Comme Conducteurs Electriques. A. Bouchon (El P–April 2.) 2000 w.

*3399. Tableau de Communications pour Moteur Compound Ill. E. Meylan (Ibid.) 1000 w.

*3400. Un Succédané du Zinc. E. D. (Ibid.) 500 w.

*3419. Voltamétre de Laboratoire a Grand Débit du Commandant Renard. Ill. (Misc.) 1200 w.

*3421. Constantes de Quelques Accumulateurs (Misc.) 2500 w.

*3422. L'Affinage du Cuivre et la Fabrication des Tubes au Moyen de l' Electrolyse. Ill. (Misc.) 1000 w.

*3427. Figures for Electric Light Production. II. Ill. W. H. Booth (E R L–April 8.) 4000 w.

3442. The Private Arc Light Plant. I. Geo. Thayer (S E–April 16.) 1250 w.

*3444. Les Lampes à Incandescence. Ill. (Misc.) 2400 w.

*3472. The Protection of Telephone Lines Against Induction. III. Karl Strecker (E L–April 8.) 700 w.

*3473. Load Diagrams of Electric Tramways and the Cost of Electric Traction. Ill. III. A. Reckenzaun (E L–April 8.) 2000 w.

*3474. The Electric Motor: A Practical Description of the Modern Dynamo Machine, More Particularly as a Motor. I. Ill. W. B. Sayers (E E L–April 8.) 3750 w.

*3475. The Meaning of the Term "Earth." Editorial (Ibid.) 850 w.

*3476. Dynamo. Electric Machinery. Ill. J. Hopkinson and E. Wilson (Ibid.) 3300 w.

3478. The New Method of Protecting Buildings from Lightning. M. D. C. Hodges (Sc–April 8.) 1100 w.

3490. Electricity and the Looms of St. Etienne, France. (E R N Y–April 23.) 800 w.

3491. Underground Wire Ducts in New York City. Ill. (E W–April 23.) 3100 w.

3492. Application of the Weston Voltmeters and Ammeters to Practical Electrical Measurements. V. Ill. H. Maschke (Ibid.) 2900 w.

3494. Current Controllers for Use in Medical Work. Ill. T. J. Waters (Ibid.) 2700 w.

3495. A Chapter in American Storage Battery History. Ill. (E E N Y–April 20.) 1100 w.

3496. The Consumption of Zinc in Batteries. F. W. Jones (Ibid.) 400 w.

3497. A Point or Two on Primary Batteries. Walter A. Crowdus (Ibid.) 1150 w.

3498. "Kobolds" in Electro-Dynamics. Frederick A. Scheffler (Ibid.) 1500 w.

3499. On the Measurement of the Power Given by Any Current to Any Circuit. Norman Whichells (Ibid.) 900 w.

3500. Theoretical Elements of Electro-Dynamic Machinery. I. Ill. A. E. Kennelly (Ibid.) 1400 w.

3501. On the Action of Vacuum Discharge Streamers upon Each Other. Ill. M. I. Pupin (Ibid.) 1900 w.

3502. Carbon Accumulators. Jas. A. Lounsbury (Ibid.) 800 w.

3523. Some Views of Central Station Work. VI. T. Carpenter Smith (Misc.) 2100 w.

3524. Electricity in the United States Navy. Ill. III. W. B. Lefroy Hamilton (Misc.) 900 w.

†3541. L'Eclairage Electrique de la Ville de Ninove. Ill. Henri Delvaux (R U M–Jan.) 2400 w.

*3548. On the Heat Produced by Eddy Currents in an Iron Plate Exposed to an Alternating Magnetic Field. J. J. Thomson (El–April 8.) 1600 w.

*3549. Note on the Use of the Electro-Dynamometer. Wm. Brew (Ibid.) 1000 w.

*3550. The Combinations of Resistances. Ill. P. A. Macmahon (Ibid.) 1000 w.

*3551. The Compound Winding Case. Editorial (Ibid.) 1000 w.

3552. Which Terminal Shall we Ground in Electric Railway Circuits? Chas. Proteus Steinmetz W E–April 16.) 1500 w.

*3554. Le Cuivre Electrolytique par le Procédé Elmore. (M I–April 12.) 800 w.

3556. Electric Railroads and Their Effects on Society. Otis K. Stuart (E A–April 23.) 1400 w.

3557. An Early Conception of the Magnetic Field. Edwin J. Houston (Ibid.) 2100 w.

3571. The Trolley System for Chicago. Ill. Frank L. Perry and Alex. Dow (W E–April 23.) 3700 w.

3572. The Electric Railway for Chicago. E. E Keller (Ibid.) 1700 w.

3573. No Overhead Wires in Chicago Streets. St. John V. Day (Ibid.) 750 w.

*3574. Les Stations Centrales d'Eclairage Electrique de la Principauté de Monaco. Ill. Emile Dieudonné (El P–April 9.) 2800 w.

*3588. Grue de Cent Tonnes Mue par l'Electricité. Ill. C. J. Bates (G C–April 9.) 1800 w.

*3589. Etude sur l'Affutage Electrique des Limes. Couteaux de Diffusion, etc. Ill. Schiebl-Treherne, (Ibid.) 2600 w.

*3601. The First News Message by Telegraph. John W. Kirk (Misc.) 3200 w.

*3698. The Tides for Electric Lighting. S. Tolver Preston (Eng L–April 15.) 1200 w.

3618. Points on Power Stations. Ill. William Lee Church (E & R–April.) 2300 w.

*3619. Some Recent Researches on Electrical Oscillations. Ill. M. M. Blondlot and Dufour (El–April 15.) 800 w.

*3620. Eddy Currents in Transformer Cores. Editorial (Ibid.) 750 w.

*3621. On Magnetic Screening, Eddy Currents, and Hysteresis, in Transformer Cores. Ill. Prof. Ewing (Ibid.) 3600 w.

*3624. Electric Meters, Motors, and Money Matters. W. E. Ayrton (Ibid.) 2200 w.

*3635. The Protection of Telephone Lines Against Induction. IV. Karl Strecker (E L–April 15.) 800 w.

*3636. Load Diagrams of Electric Tramways and the Cost of Electric Traction. IV. Ill. A. Reckenzaun (Ibid.) 1500 w.

*3647. La Cryptophonie et le Cryptophone. Ill. (Misc.) 2500.

*3649. Les Lampes Electriques d'Interieur. Ill. (Misc.) 850 w.

*3650. 1882-1892: A Comparison. Sydney F. Walker (E E L–April 15.) 2100 w.

*3651. On the Clark Cell as a Standard of Electromotive Force. R. T. Glazebrook and S. Skinner (Ibid.) 3000 w.

*3654. Tesla's Experiments. Interviews with Prominent Electricians Concerning Them (E R N Y–April 30.) 6000 w.

3655. Relative Weights and Cost of Dynamos. Ill. Carl Hering (E W–April 30.) 600 w.

3657. The Manufacture of Arc Lamps for Low Tension Circuits. Ill. (Ibid.) 1400 w.

3658. Dynamo and Motor Calculation. Ill. C. H. Bedell (Ibid.) 1400 w.

3660. Some Views of Central Station Work. VII. Ill. T. Carpenter Smith (Misc.) 2700 w.

3661. A Photographic Study of Non-Arcing Metals. Ill. Alexander Jay Wurtz (E E N Y–April 27.) 800 w.

3662. Scientific Electro-Medical Apparatus. Ill. James Bowstead Williams (Ibid.) 1000 w.

3663. Theoretical Elements of Electro-Dynamic Machinery. II. Ill. A. E. Kennelly (Ibid.) 1700 w.

3664. The Private Arc Light Plant. II. Geo. Thayer (S E–April 23.) 1500 w.

*3666. Des Dangers que Présentent les Canalisations Souterraines en Cuivre Nu. J. A. Montpellier (El P–April 16.) 1200 w.

*3667. Le Compteur Brillié (Type 1891.) Ill. L. David (Ibid.) 800 w.

*3668. La Fibre Vulcanisée dans l'Industrie Electrique. Em. Dieudonné (Ibid.) 1400 w.

*3769. Electrical Aid to Tanning. II. L. A. Groth (L M–May 1.) 1000 w.

*3778. The Electric Motor: A Practical Description of the Modern Dynamo Machine, More Particularly as a Motor. II. W. B. Sayers (E E L–April 22.) 1500 w.

*3783. Transformer Predeterminations. I. J. A. Fleming (El–April 22.) 2800 w.

*3785. Improved Quadrant Electrometer. Ill. W. E. Ayrton, J. Perry and W. E Sumpner (Ibid.) 1600 w.

*3786. A Buried Microphone. Alex. J. S. Adams (Ibid.) 550 w.

*3787. The Dangers of Bare Copper Underground Mains. J. A. Montpellier (Ibid.) 1050 w.

3791. Some Views of Central Station Work. VIII. Ill. T. Carpenter Smith (Misc.) 2400 w.

3792. Are All Metals Magnetic? Nelson W. Perry (Misc.) 1000 w.

3793. Electricity in the United States Navy. IV. Ill. W. B. Lefroy Hamilton (Misc.) 950 w.

3794. Hazards of Artificial Illumination. Geo. P. Low (P L–April 28.) 1900 w.

3802 Wiring Table for Secondary Alternating Current Circuits. H. W. Frund (E W–May 7.) 300 w.

3803. Some High Potential Phenomena. Ill. C. E. Skinner (Ibid.) 1100 w.

3805. Experiments with Alternate Currents of High Potential and High Frequency. Ill. Nikola Tesla (Ibid.) 37,500 w.

3806. The Private Arc Light Plant. III. Geo. Thayer (S E–April 30.) 1400 w.

3810. The Incandescent Lamp Suit. (E R N Y–May 7.) 7000 w.

*3811. Le Théatrophone et les Auditions Théatrales. Ill. L. Montillot (El P–April 23.) 2400 w.

3814. Long-Distance Telephony. I. Ill. Herbert Laws Webb (E E N Y–May 4.) 5600 w.

3815. Theoretical Elements of Electro-Dynamic Machinery. III. Ill. A. E. Kennelly (Ibid.) 1500 w.

3816. Recent Improvements in Quadruplex Telegraphy. Ill. Wm. Finn (Ibid.) 1100 w.

3817. Lighting with High Frequencies. Editorial (Ibid.) 1200 w.

3819. The Fisher Automatic Cut-Outs. Ill. Henry W. Fisher (Ibid.) 1800 w.

*3824. Municipal Authorities and Central Electric Light Stations. Editorial (Eng L–April 22) 1400 w.

*3837. The Gramme Machine. I. A. Ewbank (I E–April 2.) 1700 w.

*3875. The London Board of Trade Overhead Wire Regulations. Editorial (E R L April 22.) 1250 w.

*3876. Figures for Electric Light Production. III. W. H. Booth (Ibid.) 3100 w.

*3878. Electrical Distribution by Alternating Currents and Transformers. I. Rankin Kennedy (Ibid.) 2200 w.

*3879. A Practical Demonstration of the Transmission of Force by Electricity, Made in 1858 by Eugene Regnault. A. M. Tanner (Ibid.) 900 w.

*3881. The Protection of Telephone Lines Against Induction. V. Dr. Karl Strecker (E L–April 22.) 1800 w.

*3882. Load Diagrams of Electric Tramways and the Cost of Electric Traction. V. A. Reckenzaun (Ibid.) 1000 w.

3896. The Use of Electrical Expressions. D. W. J. (W E–May 7.) 1000 w.

†3914. Some Thoughts About Storage Batteries. J. K. Pumpelly (Misc.) 1100 w.

*3926. Phonoporic Telephony (I–April 22.) 1000 w

*3934. Sur les Différents Modes de Distribution de l'Electricité (Misc.) 4200 w.

*3947. Electrical-Measuring Instruments. James Swinburne (Eng L–April 29.) 1200 w.

*3948. Wave Propagation of Magnetism. Editorial (E R L–April 29.) 1800 w.

*3949. Measurement of the Lag Between Two Alternating Currents. Ill. (Ibid.) 500 w.

*3950. The Brillié Electrical Energy Meter. Ill. (Ibid.) 1300 w.

*3951. The Constants of Telegraph Apparatus. W. Moon (Ibid.) 2800 w.

*3952. Electrostenolysis (Ibid.) 800 w.

*3953. Transformer Predeterminations. II. Ill J. A. Fleming (El–April 29.) 2600 w.

*3954. Electric Traction. Editorial (Ibid.) 950 w.

*3955. Notes on Electric Percussion Drills. Ill. Albion T. Snell (Ibid.) 1500 w.

*3956. On the Retardation Due to Iron Pipes. W. H. Preece (Ibid.) 1300 w.

*3957. Notes on the Light of the Electric Arc. Ill. I. A. P. Trotter (Ibid.) 2200 w.

*3959 Les Machines à Champ Magnétique Tournant. Ill. I. (Misc.) 2400 w.

*3976. Rock Blasting by Electricity. II. Wm. L. Saunders (S–May.) 1250 w.

*4009. The Protection of Telephone Lines Against Induction. VI. Karl Strecker (E L April 29.) 500 w.

*4012. The Radiation of Electrical Energy. Ill. Fred. T. Tronton (Ibid.) 1400 w.

4029. The Armature. L. K. Comstock (S E–May 7.) 1750 w.

4033. Earth Current Disturbances in Telegraph Lines. Ill. William Finn (E A–May 14.) 2200 w.

4034. New Edison Telephone Patents. Editorial (E W–May 14.) 900 w.

4035. The Electric Current and the Human Body. Editorial (Ibid.) 900 w.

4036. Ohm's Law. Arthur G. Webster (Ibid.) 1100 w.

4037. Dynamo and Motor Calculation. Ill. J. C. Lincoln (Ibid.) 350 w.

4038. Fluctuations of the "Zero Point" of a Sensitive Galvanometer. Ill. F. J. Rogers (Ibid.) 1200 w.

4039. The Elementary Principles Necessary to Establish the Equation of Electromotive Forces for a Circuit Containing Resistance and Self-Induction. I. Frederick Bedell and Albert C. Crehore (Ibid.) 3800 w.

4041. The New Edison Telephone Patents. Ill. (Ibid.) 3500 w.

4042. The Edison Lamp Patent Case (Ibid.) 3000 w.

*4043. Sur le Couplage des Dynamos. G. Martin (El P–April 26.) 1000 w.

*4044. Lampe à Arc, Système Brianne. Ill. E. Meylan (Ibid.) 600 w.

4064. Long Distance Telephony. II. Ill. Herbert Laws Webb (E E N Y–May 11.) 9300 w.

4065. The Edison Telephone Patents. Editorial (Ibid.) 1100 w.

4066. The Cost of Electricity in Agriculture. Editorial (Ibid.) 900 w.

4067. Some Views of Central Station Work. Ill. IX. T. Carpenter Smith (Misc.) 2500 w.

*4114. The Gramme Machine. II. A. Ewbank (I E–April 9.) 1900 w.

*4119. The Financial Side of the Supply of Electricity. Sydney F. Walker (E P–May 1.) 4600 w.

*4124. The Bradford Corporation Electricity Supply. Ill. James N. Shoolbred (E E L–May 6.) 5500 w.

*4124. Escape of Electricity from Mains. Editorial (G W–May 7.) 750 w.

†4147. Human Electricity. John G. McKendrick (F R–May.) 3800 w.

*4149. Pacific Cable Schemes. Ill. (El–May 6.) 2700 w.

*4150. Notes on the Light of the Electric Arc. Ill. II. A. P. Trotter (Ibid.) 4200 w.

4185. The Magnetic Storm of February 13, 1892. Ill. S. J. Brown and J. A. Hoogewerff (Misc.) 2700 w.

4193. Electro-Plating Dynamos (E A–May 21.) 1000 w.

4194. Electromotive Force. Ill. (Ibid.) 1500 w.

4195. Governing Dynamos (Ibid.) 3600 w.

4196. Motors (Ibid.) 2700 w.

*4208. Une Grue Electrique Pivotante. Ill. Emile Dieudonné (El P–May 7.) 1300 w.

*4209. La Nouvelle Station Centrale Téléphonique de Saint-Pétersbourg. Ill. L. Montillot (Ibid. 3500 w.

*4210. L'Arc Normal et l'Arc Sifflant. Ill. J. A. Montpellier (Ibid.) 1300 w.

4218. The Electrical Plant Discovered in India (E R N Y–May 21.) 650 w.

4219. What Electricity Is. W. W. Jacques (Ibid.) 4500 w.

4220. Arguments and Models in the Edison "Feeder" and "Main" Case. Ill. (E E N Y–May 18.) 1700 w.

4221. Hewett's Improved Forms of the Porous Oil Insulator. Ill. R. J. Hewett (Ibid.) 450 w.

4223. Theoretical Elements of Electro-Dynamic Machinery. IV. Ill. A. E. Kennelly (Ibid.) 1100 w.

4224. The Secret Telegraph Receiver. Ill. A. A. Knudson (Ibid.) 700 w.

4230. A Glance at Some Electrical Features of London. Robert M'A. Lloyd (E W–May 21.) 1600 w.

4231. Corrections of Wattmeter Readings. Robert M. Friese (Ibid.) 2200 w.

4232. The Weston Voltmeter as a Testing Instrument. Ill. E. A. Merrill (Ibid.) 1700 w.

4233. The Elementary Principles Necessary to Establish the Equation of Electromotive Forces for a Circuit Containing Resistance and Self-Induction. II. Frederick Bedell and Albert C. Crehore (Ibid.) 2500 w.

4235. Some Views of Central Station Work. X. T. Carpenter Smith (Misc.) 2800 w.

4236. Light Without Heat. Editorial (Misc.) 750 w.

4237. The Candle Power of Arc Lamps. C. W. Swoope (Misc.) 550 w.

4238. Magnetic Iron: A Suggestion. W. S. Key (Misc.) 500 w.

*4241. Quelques Détails sur la Fabrication des Lampes à Incandescence. Ill. M. Falcon (Misc.) 1250 w.

*4242. Compteur Batault. Ill. (Misc.) 650 w.

4243. Electricity in Tooth Extraction (E P–May 15.) 850 w.

4244. Removal of Superfluous Hair by Electricity. Plym S. Hayes (Ibid.) 2250 w.

4251. Electric Heaters. W. H. Merrill, Jr., and F. E. Cabot (E N–May 19.) 1500 w.

*4284. A Model of the Electric Organ of the Raia Torpedo. Ill. (El–May 13.) 500 w.

*4285. The Measurement of Rapid Periodic Effects. Editorial (Ibid.) 950 w.

*4289. Electric Power Transmission in Genoa (E L–May 13.) 1750 w.

*4310. Systèmes de Distribution des Courants Alternatifs avec Emploi de Condensateurs. Ill. W. Cam. Rechniewski (El P–May 14.) 2000 w.

*4311. Disposition à Intensité Variable des Lampes à Arc en Série Deux par Deux sur 110 Volts. Ill. P. Vitte (Ibid.) 1200 w.

*4312. Le Radiomètre et Photomètre G. Segny et Verschaffel. Ill. E. Meylan (Ibid.) 600 w.

*4323. The Brillie Electrical Energy Meter. Ill. (Eng L–May 13.) 1000 w.

*4334. Researches on the Alleged Occlusion of Hydrogen by Lead in the Secondary Battery. Editorial (E R L–May 13.) 1350 w.

*4335. How Dangers from Electricity in Explosives Factories may be Avoided (Ibid.) 1500 w.

4336. Sparking and Flashing of Dynamos. Ill. F. R. M'Berty (E R N Y–May 28.) 5000 w.

4337. The Vacuum in Lamp Bulbs. Adolph Berrenberg (Ibid.) 850 w.

4338. One of Faraday's Discoveries Anticipated by Renatus Des Cartes. Ill. (Ibid.) 550 w.

4339. Electricity in a Modern New York House. Ill. T. C. Martin (E E N Y–May 25.) 3900 w.

4341. Theoretical Elements of Electro-Dynamic Machinery. V. Ill. A. E. Kennelly (Ibid.) 1600 w.

4342. The Cuttriss Carbon Relay for Submarine Cables. Ill. Chas. Cuttriss (Ibid.) 1200 w.

4343. Ampère-Centimetre, a Measure of Electro-Magnetism. Carl Hering (E W–May 28.) 860 w.

4346. Testing Board in the Department of the Inspection of Wires in the City of Boston. Ill. (Ibid.) 800 w.

4347. The Elementary Principles Necessary to Establish the Equation of Electromotive Forces for a Circuit Containing Resistance and Capacity. III. Frederick Bedell and Albert C. Crehore (Ibid.) 2500 w.

4348. Signatures of Some Prominent Foreign Electricians. (Ibid.) 700 w.

4350. Efficiency of Transformers. I. Ill. M. V. Dolivo-Dobrowolsky (Ibid.) 3300 w.

4351. Electrical Transmission of Power to the Virginius Mines. Editorial (M S R–May 19.) 1350 w.

*4353. Les Isolateurs à Huile Schomburg pour la Transmission Electrique de l'Energie. Ill. (Misc.) 1600 w.

*4354. Les Machines à Champ Magnétique Tournant. Ill. Ill. (Misc.) 2600 w.

*4356. Transmission de l'Heure Exacte par le Procédé "Foucault-Verité" (M I–May 10.) 600 w.

4364. The Distribution of Electricity for Lighting Purposes. Ill. J. Brentnall Duckitt (S E–May 21.) 3400 w.

4375. Some Views of Central Station Work. XI. Ill. T. Carpenter Smith (Misc.) 2500 w.

4376. Stored Electricity for Dental and Surgical Purposes. J. E. Stanton (Misc.) 850 w.

4377. The Telephone Monopoly. Editorial (Misc.) 750 w.

4379. Kite Electricity. P. H. Van der Weyde (Misc.) 850 w.

*4393. Transport de l'Energie Electrique à Grande Distance. Ill. G. Foris (G C–May 14.) 2000 w.

†4395. The Ether and Its Newly Discovered Properties. A. E. Dolbear (A–June.) 2750 w.

†4424. Lead Reversible Batteries. Ill. B. V. Swenson (Misc.) 2500 w.

†4427. Primary Battery Tests. Ill. W. G. Miller and W. H. Foster (Misc.) 1400 w.

4434. The Lighting by Electricity of the Buoys in Gedney's Channel, New York Harbor. Ill. (W E–May 28.) 2000 w.

4435. Bernardo's Process of Electric Welding. W. Alsop (Ibid.) 1300 w.

*4439. The Gramme Machine. III. Ill. A. Ewbank (I E–April 23.) 1600 w.

*4474. Secondary Batteries. Editorial (E May 20.) 1250 w.

*4483. Alternate Current Difficulties. Editorial (El–May 20.) 800 w.

*4484. Prof. Hertz's Researches on the Propagation of Electric Force. J. L. Howard (Ibid.) 1200 w.

*4486. Notes on W. H. Preece's Paper on Specifications for Insulated Cables. C. Heim (Ibid.) 800 w.

*4487. On the Cause of the Changes of Electro-Motive Force in Secondary Batteries. Ill. J. H. Gladstone and Walter Hibbert (Ibid.) 5500 w.

*4497. The Best Frequency for Alternating Currents. Editorial (I L–May 20.) 1400 w.

*4509. The Theory of Lead Accumulators. Editorial (E L–May 20.) 650 w.

*4510. Production of Light by Direct Transformation of Electrical into Luminous Vibrations. I. G. Schmitz (Ibid.) 1500 w.

*4512. Bradley's Multiphase Patents. Ill. (E E L–May 20.) 2300 w.

*4540. Relative Weights and Cost of Dynamos. Ill. Albion T. Snell. (E R L–May 20.) 2000 w.

*4551. Sur Quelques Découvertes Récentes Relatives aux Courants Alternatifs. Ill. Eric Gérard (El P–May 21.) 2700 w.

4552. Notes on the Magnetic Circuit. Chas. Proteus Steinmetz (E W–June 4.) 1900 w.

4553. The Elementary Principles Necessary to Establish the Equation of Electromotive Forces for a Circuit Containing Resistance and Capacity. IV. Frederick Bedell and Albert C. Crehore (Ibid.) 1500 w.

4554. Efficiency of Transformers. II. Ill. M. Von Dolivo-Dobrowolsky (Ibid.) 1300 w.

4555. Systems of Alternating Current Distribution with the Aid of Condensers. W. Camille Recknlewski (Ibid.) 1500 w.

4557. Current Selectors. Ill. (Ibid.) 1500 w.

4558. Magnetization Curves of Iron Under Alternating Currents. Ill. J. E. Moore and E. M. Tingley (Ibid.) 600 w.

4560. Central Radiation. Edwin J. Houston (E R N Y–June 4.) 3600 w.

4567. Electricity on a Southern Farm. Ill. A. F. McKissick (E E N Y–June 1.) 400 w.

4568. The Magnetic Exploring Coil. W. M. Stine (Ibid.) 900 w.

4569. Breaking Strain of Various Joints in Hard-Drawn Copper Telegraph Wires. F. W. Jones (Ibid.) 700 w.

4571. Preliminary Note on Some Tests of the Carhart-Clark Standard Cells. Ill. Percy Matthews and James E. Hewes (Ibid.) 400 w.

4572. Measurement of Resistances by Alternating Currents. Brown Ayres (Ibid.) 400 w.

4575. Resistance Standards: Their Manufacture and Adjustment. Elmer G. Willyoung (Ibid.) 1500 w.

+4580. Electric Lighting at Topeka, Kansas. Lewis Kingman, John W. Hill, E. E. Macgovern, and J. P. Barrett (Misc.) 4500 w.

4584. Some Views of Central Station Work. Ill. XII. T. Carpenter Smith (Misc.) 2100 w.

4585. The Candle Power of Incandescent Lamps. C. W. Swoope (Misc.) 750 w.

*4591. Procédé de Préparation de Filaments en Cellulose les Lampes à Incandescence. (M I–May 24.) 450 w.

*4593. Tannage Rapide du Cuir par l'Electricité. Ill. Max de Nansouty (G C–May 21.) 2700 w.

*4594. Les Fontaines Lumineuses de la Soirée de Gala du 14 Mai à l'Hotel-de-Ville. Ill. R. Audra (Ibid.) 500 w.

4619. Dynamo and Motor Calculation. Ill. C. H. Bedell (W E–June 4.) 1500 w.

4620. Constant Shunt Method for the Measurement of Large Continuous Currents. Clayton W. Pike (Ibid.) 3600 w.

*4656. Safety Fuses. Ill. Clarence P. Feldman (El–May 27.) 2500 w.

*4657. On the Cause of the Changes of Electro-Motive Force in Secondary Batteries. II. Ill. J. N. Gladstone and Walter Hibbert (Ibid.) 4000 w.

*4658. Electrical Distribution by the Newcastle-on-Tyne Electric Supply Company. A. W. Heaviside and R. C. Jackson (Ibid.) 4500 w.

*4659. The Counter Electromotive Force of the Voltaic Arc. Ill. F. Stenger (Ibid.) 800 w.

4672. Some Points for the Electrical Engineer. Horatio A. Foster (E R N Y–June 11.) 2700 w.

4674. The Ampère-Centimetre as a Unit of Magnetism. Chas. P. Steinmetz, Elihu Thomson, and Townsend Wolcott (E W–June 11.) 1100 w.

4675. The Advance of Electricity. Edwin J. Houston (Ibid.) 2400 w.

4677. An Improved Form of Dynamometer. Ill. R. O. Heinrich (Ibid.) 1900 w.

4678. Selective or Individual Signals. Ill. Thomas D. Lockwood (Ibid.) 5700 w.

4679. Some Views of Central Station Work. XIII. Ill. T. Carpenter Smith (Misc.) 2100 w.

4685. A New Three-Wire System. Ill. H. Ward Leonard (E E N Y–June 8.) 2200 w.

4686. Iron Pipes for Interior Conduits. Fremont Wilson (Ibid.) 500 w.

4687. Notes on the Determination of Wire for Multiple Arc Distribution. H. Robinson Wellman (Ibid.) 250 w.

4688. The Application of Logarithms in Calculating Sizes of Electric Conductors. Thos. J. Fay (Ibid.) 700 w.

*4690. Figures for Electric Light Production. Ill. IV. W. H. Booth (E R L–May 27.) 3100 w.

*4691. The History of Tension-Reducing Transformers. Ill. (Ibid.) 2200 w.

*4725. On the Changes Produced by Magnetization in the length of Iron and Other Wires Carrying Currents. Ill. Shelford Bidwell (E E L–May 7.) 2500 w.

*4729. Le Matériel de la Téléphonie Urbaine. I. Ill. (Misc.) 2300 w.

+4735. Dynamo and Motor Calculation. Ill. C. H. Bedell (J F I–June.) 1300 w.

*4745. Avertisseur Universel Système Digeon. Ill. Edmond Bernheim (G C–May 28.) 3700 w.

*4756. La Pile Poudroux. Ill. J. A. Montpellier (El P–May 28.) 900 w.

+4757. Recherches Electriques de l'Institut Physique et Technique de l'Empire d'Allemagne à Charlottenbourg. Dr. St. Lindeck (Ibid.) 1300 w.

*4758. Le Voltamètre à Grand Débit Renard-Ducretet. Ill. E. M. (Ibid.) 750 w.

*4781. The Gramme Machine. IV. Ill. A. Ewbank (I E–May 7.) 1900 w.

*4785. Treasury Minute on the Development of the Telephone System in the United Kingdom. (E L–June 3.) 1300 w.

*4786. Means for Preventing the Entanglement of Wires. Ill. W. Christiani (Ibid.) 800 w.

*4787. The Telephony of the Future. A. R. Bennett (E P–June 1.) 1250 w.

*4802. Applications Industrielles de l'Electricité. H. Fontaine (Misc.) 2700 w.

*4803. Le Matériel de la Téléphonie Urbaine. II. Ill. (Misc.) 1750 w.

*4825. A Portable Instrument for Measuring the Strength of Magnetic Fields, with Some Remarks on the Stray Fields of Dynamos. Ill. Edwin Edser and Herbert Stansfield (El–June 3.) 750 w.

*4835. Excavating Tunnels and Adits by Electrical Machinery. (E R L–June 3.) 1500 w.

*4839. Electricity in the Hardware Store. Herbert Laws Webb (I R W–June 15.) 1200 w.

GAS ENGINEERING.

*3405. Why Does Hot Air Supply Brighten Gas Flames? Editorial (G W–April 9.) 750 w.

*3406. Early History of Gas Lighting. William Murdoch (Ibid.) 2400 w.

3429. The Determination and Regulation of the Proper Proportions of Primary and Secondary Air and Steam in Regenerative Furnaces. Frederic Bredel (A G L J–April 18.) 5000 w.

3644. Coal Gas versus Electricity. What Do We Pay, and What Do We Get for Our Money? John W. Truesdell (A G L J–April 25.) 1100 w.

3645. Consumers' Fittings. J. H. Troughton (Ibid.) 2300 w.

*3708. The Photometry of Gas. (J G L–April 19.) 2000 w.

3770. And Again Meter Rents. Editorial (P A–May 2.) 2300 w.

3771. The Present Situation of the Gas Industry. Ill. August Lévy (Ibid.) 3600 w.

*3844. The Enrichment of Gas in Bulk by Means of Carburetters. F. W. Clark (J G L–April 26.) 1300 w.

*3874. The Influence of Air and Its Impurities on the Illuminating Power of Flames. Dr. Bunte (C T J–April 23.) 3500 w.

3974. Some Speculations on a Patent Gas Process at Newark, N. J. A. H. Stricker (A G L J–May 9.) 2000 w.

*4007. Sur la Lampe Sans Flamme Obtenue avec le Gaz d'Eclairage. M. F. Parmentier (M I–April 26.) 1200 w.

*4110. The Luminosity of Coal-Gas Flames. Vivian B. Lewes (J G L–May 3.) 7300 w.

*4111. Some Notes Upon the Action of the Sliding Scale. W. J. Warner (Ibid.) 1900 w.

*4117. Freezing of Gas Meters. Editorial (G W–April 23.) 1300 w.

*4129. Anomalies in Gas-Undertakings. V. Wyatt (G W–May 7.) 4500 w.

*4197. Should External Guide-Framing be Abolished? George Livesey (J G L–May 10.) 1700 w.

4217. The Natural Photometer. J. A. P. Crisfield (P A–May 16.) 2700 w.

*4314. The Gas Industry in European Cities. (G E M–May 10.) 3500 w.

*4315. Old Lights and New. Councillor Gibson (Ibid.) 3300 w.

4449. Gas Burners. J. A. Faux (Met W–May 28.) 2800 w.

*4520. Differential Rates. Editorial (G W–May 21.) 1800 w.

*4521. Notes on Oil-Gas Manufacture. A. F. Browne (Ibid.) 3500 w.

4598. The Construction and Operation of Half-Depth Regenerative Furnaces for Firing with Cheap Coal. W. H. Odiorne (P A–June 1.) 1400 w.

4599. The Advantages of Recuperative Furnaces in the Utilization of Heat. Ill. Fred. Bredel (Ibid.) 3000 w.

4600. Practical Photometry Simplified for Daily Use. Ill. B. E. Chollar (Ibid.) 2500 w.

4601. Every-Day Gas Analysis. Ill. Wm. A. Stedman, Jr. (Ibid.) 1050 w.

4603. Petroleum Products—Hydro-Carbon Employed in Gas Manufacture. C. M. Higgins (Ibid.) 1050 w.

4604. Fuel Gas as Viewed Through a Coal Gas Man's Spectacles. Ill. K. M. Mitchell (Ibid.) 2300 w.

*4721. The Use of Oil for Carburetting Gas. Vivian B. Lewes (G W–May 28.) 3000 w.

*4722. Notes on the Enrichment of Coal Gas with Liquid Hydrocarbons. T. S. Lacey (Ibid.) 4000 w.

*4723. The Comparative Value of Various Oils for Enriching Coal Gas. E. Llewellyn Pryce (Ibid.) 2500 w.

4772. Gas for Heating and Cooking (Met W–June 11.) 3800 w.

*4823. The Technology of Water Gas. Arthur Matthews Paddon and Thomas Goulden (G W–June 4.) 4700 w.

*4824. Oil in the Manufacture of Gas. Discussion before the Incorporated Institution of Gas Engineers (Ibid.) 7900 w.

HYDRAULICS.

*3435. A New Method of Hydraulic Propulsion. Ill. Alexander Vogelsang (Eng L–April 8.) 850 w.

*3450. Waterworks Fittings and Appliances. II. A. Fairlie Bruce (M W–April 8.) 1000 w.

3506. A Large Water Softening Plant. Ill. (E N–April 16.) 3100 w.

3707. Fort Worth's Water System. John B. Hawley (F W–April 30.) 1500 w.

†3745. The Newport Water Supply. Thomas M. Drowne (San–May.) 5000 w.

*3845. The Minimum Size of Water-Mains and the Laying of Mains, Hydrants, etc., for the Protection of Property from Fire. "Inspector" (J G L–April 26.) 2000 w.

3895. Water-Wheel Gates, Guides and Cases. John B. M'Cormick (M R–May 6.) 2700 w.

4080. The Covered Water-Works Reservoir at Franklin, N H. Ill. (E N–May 12.) 1700 w.

†4113. London Water Supply. Editorial (Misc.) 1300 w.

†4200. Some Reasons Why, in Designing and Operating a System of Water Works for the Domestic Supply of a Municipality, Provision Should Not be Made for furnishing Water Therefrom Under Pressure to Operate Elevators and Other Motors. J. Nelson Tubbs (J N E W–June.) 5400 w.

†4201. Economy in Water Works Management. Solon M. Allis (Ibid.) 1600 w.

†4202. The Frictional Head in a Force-Main. F. F. Forbes (Ibid.) 2300 w.

†4203. Standard Specifications for Water Works. E. H. Gowing (Ibid.) 6500 w.

†4204. Sixteen-Inch Direct River Pipe and Its Effect upon the Taunton Supply. George P. Chace (Ibid.) 1600 w.

†4205. An Experience with a Water-Meter. L. A. Taylor (Ibid.) 450 w.

†4206. Description of a Well to Supply the City of Waltham, Mass. Ill. Frank L. Fuller (Ibid.) 1100 w.

†4207. Laying a Thirty-Inch Supply Main. S. P. Griffin (Ibid.) 650 w.

4257. Particulars in which Municipal Officers Should Protect the Municipal Corporation in Granting Water-Works Franchises to Private Companies. J. Nelson Tubbs (E N–May 19) 2300 w.

4258. Protection of Exposed Water Mains Crossing Bridges. Ill. S. E. Babcock (Ibid.) 2300 w.

4269. Water Pressure and Water Distribution. Peter Milne (F W–May 21.) 2100 w.

4275. Extract from a Paper on Tangential Water Wheels. Ill. Ross E. Browne (F & M R–May 21.) 1800 w.

4400. The New Water Supply for Atlanta. W. G. Richards (E N–May 26.) 1900 w.

4404. Notes on a Problem in Water Power. John Richards (Ibid.) 1900 w.

4411. Gates on Force Mains. C B. Brush (Ibid.) 1000 w.

4463. The Water Supply of New Orleans. A. L. Metz (F W–May 28.) 1400 w.

4464. Combination System of Meter Rates. James P. Donahue (Ibid.) 1500 w.

*4469. The Royal Commission on the London Water Supply (E–May 20.) 1400 w.

*4470. Sand-Washing Apparatus for Filter Beds. Ill. (Ibid.) 500 w.

*4477. The Birmingham Water Supply Bill (Ibid.) 1250 w.

†4561. Formula for Water Power. W. P. Trowbridge (S M Q–April.) 300 w.

*4595. La Pompe Centrifuge à Vapeur "Invincible." Ill. Henri Maury (G C–May 21.) 1700 w.

4609. The New Croton Dam for the New York Water Supply. Ill. (E N–June 2.) 2300 w.

4614. Some of the Circumstances Affecting the Quality of a Water Supply. Geo. F. Rafter (Ibid.) 2400 w.

4638. Reservoir Dams. W. B. Rider (F W–June 4.) 1900 w.

*4670. The Water Resources of London. Editorial (Eng L–May 27.) 1400 w.

*4746. Installation de Filtrage des Eaux à Libourne. Ill. F. Delannoy (G C–May 28.) 1800 w.

4784. A Few Simple Suggestions as to Water Supplies and Their Use and Abuse. C. Monjeau (F W–June 11.) 3100 w.

INDUSTRIAL CHEMISTRY.

*3408. Sur l'Essai des Minerais d'Antimoine. Ad. Carnot (M I–April 5.) 1000 w.

*3409. Sur les Carbures Pyrogénés Formés dans l'Industrie du Gaz Comprimé. A. Brochet (Ibid.) 950 w.

3511. Azoimide. The New Sodium Salt, the Most Highly Explosive Substance Known. A. E. Tutton (R P–April 15.) 3500 w.

*3622. The Chemical and Physical Properties of Rosin Oil (El–April 15.) 1000 w.

3772. A New Process for Separating Carbonic Oxide from Water Gas. Henry S. Blackmore (P A–May 2.) 3600 w.

*3923. Recent Advances in Physical Chemistry. W. Ostwald (Misc.) 5500 w.

*3942. Discovery of a New Element (C T J–April 30.) 700 w.

†3971. Notes upon the Estimation of Chlorine in Electrolyzed Solutions. L. M. Norton (T Q–Dec.) 1400 w.

*3983. The Chemical Changes Attending Photographic Operations. I. The Theory of Development in Relation to the Essentially Electrolytic Character of the Phenomena and the Nature of the Photographic Image. Henry E. Armstrong (B J P–April 29.) 4000 w.

*4017. Gold-Lined Stills for Concentrating Sulphuric Acid. G. Lunge (I L–April 29.) 1100 w.

†4020. Cellulose or Wood Fibre. S. P. Sadtler (J F I–May.) 3400 w.

†4045. Recent Theories of the Sulphuric Acid Process. Wm. R. Potter (J A C S–Feb.) 3300 w.

†4046. A Remarkable Water for Public Use. A. A. Breneman (Ibid.) 500 w.

4081. Chemistry in the Foundry. I. Joseph Torrey (A M–May 12.) 1400 w.

†4090. The Colors and Absorption-Spectra of Thin Metallic Films and of Incandescent Vapors of the Metals; with Some Observations on Electrical Volatility. Wm. L. Dudley (A C J–March.) 2400 w.

†4091. The Volume Lag and Its Bearing on Molecular Constitution. C. Barns (Ibid.) 4900 w.

†4092. On the Copper Sulphites. Spencer B. Newbury (Ibid.) 2500 w.

*4121. The Chemistry of Rubber Ingredients and Adulterants III Litharge, Red Lead and White Lead. Henry J. Williams (I R W–May 15.) 2600 w.

*4125. Chemical Equilibrium in Mixed Electrolytes (E R L–May 6.) 1600 w.

*4126. Prof. Ostwald on Recent Advances in Physical Chemistry (Ibid.) 900 w.

4133. The Chemistry of Paving-Brick Manufacturing. M. D. Burke (P–May.) 400 w.

*4136. Parkinson's Oxygen Gas Process (I–May 6.) 1900 w.

*4172. Improved Methods for the Concentration of Sulphuric Acid (I L–May 6.) 1250 w.

4460. New Rapid Method for the Determination of Phosphorus in Iron, Steel, and Ores. James O. Handy (E M J–May 28) 1400 w.

*4500. The Campbell-Boyd Chlorine Recovery Process (I L–May 20.) 1800 w.

*4501. Dangers of Chemical Industries (Misc.) 1400 w.

*4503. La Fabrication de la Soude par Électrolyse de Marx et Kellner. Ill. (Misc.) 1250 w.

*4711. The New Element, Masrium. A. E. Totten (Misc.) 1500 w.

†4742. Analyses of Glass Used in the Manufacture of Incandescent Electric Lamps. Durand Woodman (J A C S–March.) 500 w.

4743. Chemistry in the Foundry. II. Joseph Torrey (A M–June 9.) 1000 w.

4776. Electro-Chemical Manufacture of Chlorate of Potash at Vallorbes, Switzerland. Ill. A. C. Knapp (E M J–June 11.) 1100 w.

*4838. The Chemistry of Rubber Ingredients and Adulterants. IV. Sulphur. Ill. Henry J. Wilhams (I R W–June 15.) 2300 w.

INDUSTRIAL SOCIOLOGY.

*3410. La Loi sur les Syndicats. Urbain Guérin (M I–April 5.) 1200 w.

*3425. La Liberté Commerciale et la Richesse de la France. D. Zolla (Misc.) 1300 w.

*3439. British and American Trade. Editorial (E–April 8.) 3300 w.

*3441. The Trade Relations of England and America. Robert McCormick (Ibid.) 6100 w.

*3453. The Strike of the Durham Miners. Editorial (C G–April 8.) 2100 w.

3459. Labor and Its Grievances. Henry Holmes (M N–April 15.) 2000 w.

*3470. German Insurance Against Industrial Accidents. Editorial (I L–April 8.) 1200 w.

*3471. Government and the Telephone. Editorial (Ibid.) 1600 w.

*3477. Who Should Build the Country Roads? Clem Studebaker (G R–April.) 3000 w.

3482. Government Timber Tests. David A. Wells, Edward Atkinson and Wm. Kent (E M J–April 16.) 1400 w.

3555. Foreigners' Rights Under the U. S. Patent Laws. F. A. Seely (I Age–April 19.) 1600 w.

3579. Government Timber Tests. R. Q. Mills, Abram S. Hewitt, "Anti-Bellamy," and Editorial (E M J–April 23.) 2000 w.

*3612. Ten Years of the Standard Oil Trust S. C. T. Dodd (F–May.) 4300 w.

†3613. Does the Factory Increase Immorality? Carroll D. Wright (Ibid.) 2000 w.

†3614. Incalculable Room for Immigrants. Edward Atkinson (Ibid.) 4300 w.

†3616. My Business Partner, the Government. Ulysses D. Eddy (Ibid.) 2600 w.

*3629. Compulsory Boiler Inspection. Editorial (E–April 15.) 1400 w.

3702. Registration of Plumbers in Great Britain. Alexander Malcolm Scott (Met W–April 30.) 2700 w.

3725. Misguided Mining Legislation in West Virginia. J. W. P. (M R–April 29.) 1000 w.

3763. The Budd Case. Majority and Minority Opinions of the Supreme Court. (R R–April 30.) 3900 w.

3764. State Regulations of Rates. Editorial (Ibid.) 1000 w.

3773. Accidents to Work People. Report by Commercial Agent Loomis, of St. Etienne (P A–May 2.) 1900 w.

†3789. The Use of Public Ways by Private Corporations. Samuel Leland Powers and Solomon Schindler (A–May.) 5800 w.

†3790. The Strength and Weakness of the People's Movement. Eva McDonald-Valesh (Ibid.) 2600 w.

†3857. Public Rights in Private Property. R. M. Fisher (Misc.) 2400 w.

†3859. Street Railway Taxation. J. B. (Misc.) 2500 w.

3860. Minority Report on the Fifthian Free-Ship Bill. Louis E. Atkinson and Geo. D. Perkins (Sea–May 5.) 1400 w.

*3870. Labor Legislation in the Netherlands. Editorial (E–April 22.) 2100 w.

*3872. The McKinley Tariff. Editorial (Ibid.) 2000 w.

*3873. Notes on Recent Experience with Some of Her Majesty's Ships. II. Ill. (Ibid.) 2800 w.

3960. Government Timber Tests. B. E. Fernow, R. W. Raymond, and Editorial (E M J–May 7.) 3500 w.

*4016. The Legal Liability of Employers for Accidents to Workmen. Editorial (I L–April 29.) 600 w.

*4069. Skilled Labor on the Pacific Coast. (I S F–May.) 2500 w.

†4071. The Protectionists of New South Wales. Sir Henry Parkes (C R–May) 3500 w.

4106. (*Price of this article: $1, or seven coupons.*) River and Harbor Bills. Emory R. Johnson (A A A–May.) 12,000 w.

†4112. The House of Commons on the Rating of Machinery. Editorial (Misc.) 2400 w.

*4123. The Government and the Telephone in England. (E E L–May 6.) 3000 w.

4167. The Conflict of Interstate and State Regulation of Railroads. W. D. Dabney (R R–May 14.) 3300 w.

4169. Are Railways Highways? Editorial (Ibid.) 1150 w.

*4173. Wages and Results in the Coal Trade. Editorial (Eng L–May 6.) 2600 w.

*4174. The Cause of Strikes. Editorial (Eng L–May 6.) 1900 w.

*4187. The Working of the Department of Labor. Carroll D. Wright (Cos–June.) 5800 w.

*4264. The Municipal Problem in America. Lewis G. Janes (Misc.) 4000 w.

4298. Governmental Operation of Railways. Editorial (R R–May 21.) 1600 w.

*4305. Labor Legislation in France. Editorial (E–May 13) 1900 w.

*4317. The Failure of the Wages System of Payment and the Remedy—Profit Sharing. George Livesey (G W–May 14.) 4200 w.

4374. Wages Paid in Foundries from Maine to California. (Misc.) 700 w.

4412. Road Legislation. F. M. Pennock (M R–May 27.) 1000 w.

*4472. The Recent Movements of Labor. Editorial (E–May 20.) 1800 w.

*4498. The Profits of Manufacturing Industry. Editorial (I L–May 20.) 1200 w.

*4526. The Durham Strike in Relation to the Miners' Federation. (C G–May 20.) 800 w.

*4527. The Mineral Clauses of the Great Western Railway Bill Hearing before the House of Commons Committee on Private Bills. (Ibid.) 14,000 w.

4625. What is the Interstate Commerce Law Good For? Editorial (R G–June 3.) 1800 w.

*4705. The Durham Miners' Strike and Its Disastrous Effects upon Trade. (C G–May 27.) 2200 w.

*4797. Recent American Shipping Legislation. Editorial (I L–June 3.) 1200 w.

*4815. The Durham Strike. Editorial (Eng L–June 3.) 1500 w.

LANDSCAPE ENGINEERING.

4769. Country Homes. Edward D. Bolton (A & B–June 11.) 2000 w.

MARINE ENGINEERING.

*3373. The Modern Marine Boiler. Ill. A. B. Willits (E Mag–June.) 3000 w.

*3383. Grandes Dragues Marines des Construction Française. Ill. L. Muller (G C–April 2.) 2800 w.

*3417. The Japanese Coast Guard Ships "Itsukushima," "Matsushima," and "Hashidate" (M E–April 1.) 1000 w.

*3428. The Compass: Historical, Theoretical, Practical. D. Wilson-Barker (E R L–April 8.) 3600 w.

*3434. On Balancing Marine Engines and the Vibration of Vessels. Ill. A. F. Yarrow (Eng L–April 8.) 4000 w.

*3436. The New American Warships. G. W. C. (Ibid.) 1800 w.

*3440. On Divisional Water-Tight Bulkheads, as Applied to Steamers and Sailing-Vessels. B. Martell (E–April 8.) 4600 w.

3510. Whaleback Imitators. Ill. (Sea–April 21.) 1200 w.

*3627. Notes on Recent Experience with Some of Her Majesty's Ships. I. W. H. White (E–April 15.) 3800 w.

*3628. Steadying Vessels at Sea. Ill. J. I. Thornycroft (Ibid.) 3500 w.

*3731. Coast and Inland Yachting. Ill. Frederic W. Pangborn (C M–May.) 7500 w.

*3825. Speed in the Navy. Editorial (Eng L–April 22.) 1800 w.

*3998. Whaleback Steamers. Ill. F. C. Goodall E–April 29.) 3300 w.

*4014. Vibration in Steamships. Editorial (I L–April 29.) 1100 w.

*4022. Asbestos in Marine Engineering. J. Alfred Fisher (M E–May 1.) 2800 w.

*4023. Thirty-third Session of the Institution of Naval Architects (Ibid.) 6500 w.

*4164. Theoretical Effect of the Race Rotation on Screw-Propeller Efficiency. Ill. R. E. Froude (E–May 6.) 5100 w.

*4177. Note upon the Data of Some Recent Steam Vessel Trials. Robert Mansel (Eng L–May 6.) 1200 w.

*4287. Screw Propulsion with Non-Reversible Engines. Robert McGlasson (I L–May 13.) 1250 w.

*4288. Report Upon Trial of the P. S. "Ville de Douvres." I. Ill. Alex. B. W. Kennedy (Ibid.) 1700 w.

*4308. Convenient Curves for Determining the most Suitable Dimensions for Screw Propellers. Ill. R. E. Froude (E–May 13.) 700 w.

*4321. A Dangerous Experiment in Naval Engine-Room Organization. Editorial (Eng L–May 13.) 2100 w.

*4391. Opérations Executées pour le Relèvement du Trois-Mâts Charbonnier "la Fédération." Ill. G. F. (G C–May 14.) 1050 w.

*4392. La Navigation Electrique. Max de Nansouty (Ibid.) 2200 w.

*4471. The Failure of Navy Boilers. Editorial (E–May 20.) 4300 w.

*4480. Engine Performances of Three Second-class Cruisers Recently Added to the British Navy. Ill. John G. Liversidge (Ibid.) 3500 w.

*4496. Report Upon Trial of the P. S. "Ville de Douvres." II. Ill. Alexander B. W. Kennedy (I L–May 20.) 2900 w.

4607. Machinery for the Naval Academy Practice Cruiser "Bancroft." Ill. (A M–June 2.) 1900 w.

4618. A Trip Under Water in an Electrically Driven Submarine Boat. Ill. (W E–June 4.) 1000 w.

*4652. The New Thames Passenger Steamer "Kohinoor." Ill. (E–May 27.) 1800 w.

*4668. H. M. S. Royal Sovereign. Ill. (Eng L–May 27.) 2500 w.

*4681. Experiments with Basic Steel. W. H. White (I–May 27.) 10,000 w.

*4712. Torpedo Boats in War. W. Laird Clowes (Inv–May 28.) 1300 w.

*4713. Asbestos in Marine Engineering. J. Alfred Fisher (Ibid.) 2000 w.

*4716. Report Upon Trial of the P. S. "Ville de Douvres." III. Ill. Alexander B. W. Kennedy (I L–May 27.) 3000 w.

4724. Submarine Boats. (Misc.) 1900 w.

*4798. Shallow Draught Gunboat for the French Government (I L–June 3.) 1100 w.

4805. River Traffic and River Steamers. Wm. H. Bryan (Misc.) 2400 w.

MECHANICAL ENGINEERING.

3445. The Necessity of a Standard Rule for Belting. C. R. Tompkins (Misc.) 1500 w.

*3449. On Some New Forms of Bends and Junctions in Tubular Construction. Ill. J. Miller Adam (M W–April 8.) 1700 w.

3516. Planing and Milling Irregular Forms. Ill. Fred J. Miller (A M–April 21.) 1300 w.

3517. On the Cultivation of Inventive Capacity by the Solution of Constructive Problems. Ill. Leicester Allen (Ibid.) 1600 w.

*3607. Fibre Cleaning Machinery. B. (Eng L–April 15.) 1200 w.

*3665. Mechanical Flight. S. P. Langley (Cos–May.) 2900 w.

*3672. Dynamomètre de Rotation de MM. Richard Frères. Ill. A. Gouilly (G C–April 16.) 1200 w.

3674. A Boring Device. Ill. A. D. Pentz (Misc.) 1300 w.

3675. Making Metal Wheels. Ill. B. F. Spaulding (A M–April 28.) 1500 w.

3678. Screw Cutting. "A Mechanic" (Ibid.) 800 w.

*3822. The Improvement of Belting. Dormant. (Eng L–April 22.) 1100 w.

3828. The Mechanical Sphere. Ill. A. D. Pentz (A M–May 5.) 2300 w.

3829. To Mold a Spiral Post. Ill. S. Bolland (Ibid.) 500 w.

3830. Pattern Making. III. P. S. Dingley (Ibid.) 700 w.

3851. Fabrication des Cycles. Ill. I. Félix Beaujouan and Yves Guédon (G C–April 23.) 2300 w.

*3868. Sizes of Pulleys for Wire Ropes. Hawser (E–April 22.) 1600 w.

*3927. Dry-Air Refrigerating Machinery; Its Commercial Value. I. Ill. W. G. Quicke (I–April 22.) 4700 w.

*3932. Le Chatelier's "Influence of Temperature on the Mechanical Properties of Metals." (Ibid.) 2000 w.

*3960. Dry-Air Refrigerating Machinery: Its Commercial Value. II. Ill. W. G. Quicke (I–April 29.) 5000 w.

*4006. Sur une Méthode pour la Détermination des Eléments Mécaniques des Propulseurs Hélicoïdaux. S. Drzewiecki (M I–April 26.) 1300 w.

4074. A Compass for Describing Ellipses. Ill. A. J. Wiley. (E N–May 12.) 600 w.

4082. The Maximum Variation in Size of Rough Iron for U. S. Standard Bolts. Ill. (A M–May 12.) 1500 w.

4083. Rubber Pattern Work. Ill. (Ibid.) 2000 w.

4086. A Revolution Counter. Ill. Albert A. Cary (Ibid.) 350 w.

4087. Good Screws in Bad Places. "Easy Way" (Ibid.) 900 w.

4102. A Hand-Telescope for Stadia-Work. Ill. Robert H. Richards (E M J–May 14.) 2200 w.

*4127. Application of Electricity to Hoisting Machinery. Reginald Bolton (E R L-May 6.) 3100 w.

4166. Belt Speed and Tension. C. R. Tompkins (M N-May 15.) 1400 w.

*4176. How a Locomotive is Propelled. Ill. A. G. Greenhill and Anthony S. Bower (Eng L-May 6.) 1100 w.

4189. The Buzz Planer. John M. Richardson (A M-May 19.) 1200 w.

4190. On Compounding Centrifugal and Load Governing by a Rotary-Piston Valve. Wm. S. Aldrich (Ibid.) 2300 w.

4192. Pattern Making. IV. Ill. P. S. Dingey (Ibid.) 700 w.

4245. A New Self-Lubricating Bearing. (E N-May 19.) 3100 w.

4246. A Standard Method of Conducting Locomotive Tests. Ill. (Ibid.) 6000 w.

4248. The Measurement of Power. Ill. Thos. Gray (Ibid.) 1650 w.

4250. An Experimental Locomotive. Ill. W. M. F. Goss (Ibid.) 2000 w.

4263. Notes on Machine Shop Practice. A. D. Pentz (M R-May 20.) 1500 w.

4270. Locomotive Testing Laboratories. Arthur T. Woods (R G-May 20.) 1150 w.

4300. Expansion Bolts. Ill. (R R-May 21.) 750 w.

*4307. President's Address Before the Institution of Mechanical Engineers. I. William Anderson (E-May 13.) 5200 w.

*4319. The Mechanics of Locomotive Traction and Driving. Ill. I. Robert H. Smith (Eng L-May 13.) 3900 w.

4383. Sixteen-Inch Gun Lathe. Ill. (A M-May 26.) 1900 w.

4384. The Form of Brass Furnaces. Alex. Cairns (Ibid.) 700 w.

†4387. Des Laboratoires de Mécanique Appliquée et de ce qui Manque au Jeune Ingénieur. Henri Witmeur (R U M-April.) 2300 w.

4417. Notes on Machine-Shop Practice. Albert D. Pentz (M R-May 27.) 1900 w.

†4430. Relative Efficiency of Different Cutting Angles in Lathe Tools. Ill. E. S. Keene (Misc.) 1000 w.

4436. Application of Electricity to Hoisting Machinery. Reginald Bolton (W E-May 28.) 2200 w.

*4479. President's Address Before the Institution of Mechanical Engineers. William Anderson (E-May 20.) 4100 w.

*4490. Patent Differential Motion for Textile Machinery. Ill. (Inv-May 21.) 1400 w.

*4513. Bearing Metals and Alloys. Editorial (Misc.) 1250 w.

†4563. The Path of a Locomotive Crank-Pin. Ill. George F. D. Trask (S M Q-April.) 250 w.

*4592. Appareils de Compression d'Air pour la Compagnie Parisienne de l'Air Comprimé. Ill. L. de Thunimont (G C-May 21.) 1900 w.

4627. Rope Gearing. M. K. Thanewala (M N-June 1.) 1400 w.

*4661. A Self-Lubricating Fibre-Graphite for Bearings of Machinery. John H. Cooper (I S F-June.) 3700 w.

4693. The Measurement of Power. Ill. Thomas Gray (R R-June 4.) 1700 w.

4710. A Few Words to Engineers and Mechanics on Lubrication. C. Verniaud (Misc.) 1300 w.

*4714. New Rules Issued by Lloyd's for the Strength of Boilers (Misc.) 700 w.

*4715. The Chinese as Mechanical Engineers (M W-May 27.) 1500 w.

4771. Joint Wiping. Ill. J. W. Hughes (Met W-June 11.) 3200 w.

*4813. The Mechanics of Locomotive Traction and Driving. II. Ill. Robert H. Smith (Eng L-June 3.) 5300 w.

*4846. Intuition in Machine-Designing. John T. Hawkins (E Mag-July.) 3000 w.

METALLURGY.

3401. The Value of Washed Fuel in the Blast Furnace. Harry S. Fleming (M R-April 15.) 2500 w.

*3462. Metals at High Temperatures. Ill. W. C. Roberts-Austen (Misc.) 7500 w.

*3480. The Alloys of Iron and Tetanium. J. B. Nau (I-April 8.) 2200 w.

*3481. Ancient Method of Silver-Lead Smelting in Peru. Otto F. Pfordte (Ibid.) 2000 w.

3483. Researches as to the Properties of Alloys. II. Ill. W. C. Roberts-Austen (E M J-April 16.) 4900 w.

†3542. Dosage Densimétrique du Phosphore dans les Fontes. Emile Ed. Metz (R U M-Jan.) 2200 w.

†3543. Emploi du Ferro-Silicium dans les Fonderies. Recherches de M. Jungst. Résumé par M. Krawtzoff (Ibid.) 2700 w.

†3544. Application du Procédé Bessemer Basique à la Metallurgie du Plomb. Procédés Rœsing (Ibid.) 1150 w.

†3545. Applications de l'Electricité aux Mines et à la Métallurgie. Ill. Emile Masson (R U M-Feb.) 1700 w.

3575. Apparatus for the Reduction of Argentiferous and Other Zinc Ores. Ill. (F & M R-April 23.) 1200 w.

3587. Watt's Electrolytic Process for Zinc Ores (E M J-April 23.) 1000 w.

*3602. The Determination of Cobalt in Manganese Ores. Thomas Moore (I-April 15.) 1500 w.

*3603. New Separation of Zinc and Manganese. P. Jannasch and R. Niederhofheim (Ibid.) 600 w.

3659. Electro-Metallurgy. I. Ill. F. M. F. Cazin (E W-April 30.) 3300 w.

*3671. L'Aluminium; Prix de Revient; Nouveau Procédé de M. Faure. Henry Thivel (G C-April 16.) 2200 w.

3804. Electro-Metallurgy. II. F. M. F. Cazin (E W-May 7.) 1150 w.

3833. Lixiviation of Gold Ores. C. H. Aaron (M S P-April 30.) 950 w.

3835. Saving Float Gold. Editorial (Ibid.) 550 w.

*3883. Thoferhn's Process for Electrolytic Copper Refining. I. (E L-April 22.) 2300 w.

*3929. The Lechesne Nickel-Steel Process (I-April 22.) 1000 w.

3933. The Refining of Sulphides Obtained in the Lixiviation Process with Hyposulphite Solutions. C. A. Stetefeldt (M S R-April 28.) 1700 w.

*3935. Employment of Ferro-Silicium in Foundries. I. M. Krawtzoff (C G-April 22.) 1200 w.

*3958. Le Magnésium et les Métaux Alcalins-Terreux par Electrolyse. Ill. (Misc.) 1100 w.

3961. The Assay of Ores of Antimony. Ad Carnot (E M J-May 7.) 1000 w.

3963. The Patio Process Modified. Ernest du B. Lukis (Ibid.) 2300 w.

3964. Parting Bullion. Ill. F. Gutzkow (Ibid.) 2900 w.

*3992. Metallurgy and Mining in Australia. Wm. M. Hamlet (I-April 29.) 2500 w.

*3993. The "Ore Process" in the Basic Open-Hearth Furnace. Dr. Leo (Ibid.) 1600 w.

*4008. Extraction du Nickel par Voie Electrolytique. I. (M I-April 26.) 1800 w.

*4010. Thofehrn's Process for Electrolytic Copper Refining. II. (E L-April 29.) 1750 w.

*4011. Cheap Primary Battery with Cupric Oxide of Great Constancy, and Automatic Regeneration of Cupric Oxide. Dr. Boettcher (Ibid.) 1100 w.

4025. Ore Separation by Magnetism (M S R-May 5.) 1000 w.

4040. Electro-Metallurgy. III. F. M. F. Cazin (E W-May 14.) 900 w.

*4137. Open-Hearth Steel Castings. H. L. Gault and J. A. Herrick (I-May 6.) 2100 w.

*4229. Extraction du Nickel par Voie Electrolytique. II. (M I-May 3.) 900 w.

4254. An Experiment with Aluminum. W. W. Christie (E N-May 19.) 800 w.

4260. Utilization of the Texas Lignites (M R–May 20.) 2500 w.

4278. Secret Process for Working Comstock Ore. Dan De Quille (E M J–May 21.) 1500 w.

4349. Electro-Metallurgy. IV. Ill. F. M. F. Cazin (E W–May 28.) 2600 w.

*4355. Séparation Electrolytique de l'Or, Procédé Smith et Muhr (M I–May 10.) 400 w.

*4366. The Relative Cost of Pig Iron and Slag. Walter J. May (C G–May 13.) 2800 w.

*4370. Production of Cast Steel in Small Quantities. C. Walrand and M. Légénisel (Ibid.) 1050 w.

4371. The Rocky Mountain Lead Industry (Misc.) 1700 w.

4373. The New Form Siemens Furnace. John Head (Misc.) 650 w.

4403. Desulphuration of Pig Iron by Manganese. Ill. F. H. Mason (E N–May 26.) 2800 w.

4450. Silicon in Cast Iron. W. J. Keep (Met W–May 28.) 1800 w.

*4502. Le Prix de Revient de l'Aluminium (Misc.) 1150 w.

*4524. Cracks and Holes in Steel Castings. M. L. Campredon (C G–May 20.) 1100 w.

4556. Electro-Metallurgy. V. Ill. F. M. F. Cazin (E W–June 4.) 2500 w.

*4590. Sur les Lois de l'Electrolyse. M. A. Chassy (M I–May 24.) 900 w.

*4680. Presidential Address before the Iron and Steel Institute. Frederick Abel (I–May 27.) 6000 w.

*4682. The Production of Pure Iron and Steel. H. Dyer (Ibid.) 2200 w.

*4683. Experiments on the Elimination of Sulphur from Iron Edwin J. Ball and Arthur Wingham (Ibid.) 4400 w.

*4702. The Ore Process. M. Brustlein (C G–May 27.) 1600 w.

*4719. Professor Wiborgh's Air Pyrometers. Ill. John Crum (I L–May 27.) 3500 w.

†4733. An Improved Method of Determining Small Percentages of Silver and Gold in Base Metals. Mattes, Etc. Cabell Whitehead (J F I–June.) 1500 w.

4777. Introduction and Development of Magnetic Separation of Iron Ore. I. Axel Sahlin (E M J–June 11.) 1900 w.

*4799. A Practical Slide-Rule for Use in the Calculation of Furnace Charges. Ill. Arthur Wingham (I–June 3.) 1700 w.

*4800. Valves for Gas-Furnaces. J. W. Warles (Ibid.) 1600 w.

MILITARY ENGINEERING.

*3374. Testing Guns at Sandy Hook. Ill. F. A. C. Perrine (E Mag–June.) 3000 w.

*3385. Essais de Tir sur des Plaques de Blindage en Acier Special, à Sevran-Livry. Ill. L. Baclé (G C–April 2.) 3100 w.

*3438. Modern United States Artillery. IV. Ill. (E–April 8.) 1600 w.

*3309. Military Aeronautics. Editorial (Eng L–April 15.) 1300 w.

*3610. Controlled Torpedoes. Editorial (Ibid.) 1100 w.

*3626. Modern United States Artillery. V. Ill. (E–April 15.) 3000 w.

†3691. The Military Geography of Canada. Arthur L. Wagner (J M S I–May.) 17,000 w.

†3692. Position-Finding and Position-Designating Service. Henry L. Harris and S. E. Allen (Ibid.) 2200 w.

†3693. Infantry Fire. Arthur MacArthur, Jr., and A. S. Frost (Ibid.) 2000 w.

†3694. The Dual Nature of Coast and Harbor Defense. Henry L. Abbott and E. M. Weaver (Ibid.) 4200 w.

†3695. Military Small Arms. Ill. G. V. Fosbery (Ibid.) 12,500 w.

†3696. Russian Experiments with Field Mortars Against Field Fortifications. (Ibid.) 4500 w.

†3697. Photography and Reconnaissance. F. J. Davies (Ibid.) 2100 w.

*3762. Chronographe Electro-Balistique. M. W. Schmidt (M I–April 19.) 600 w.

*3784. The Telegraph and the Army. Editorial (El–April 22.) 1100 w.

*3788. The Telephone at Home and in the Field C. F. C. Beresford (Ibid.) 2300 w.

*3400. Sea-Coast Batteries. II. Joseph M. Califf (R A E J–May.) 2700 w.

3801. Suggestions for a Naval Policy. Bally Hoo (A & N R–April 30.) 1400 w.

*3852. La Tourelle Oscillante de la Compagnie des Forges de Saint Chamond. Ill. G. Foris (G C–April 23.) 2500 w.

*3867. Modern United States Artillery. VI. Ill. (E–April 22.) 2900 w.

*3871. Field Howitzers and Mortars. Editorial (Ibid.) 1500 w.

*3994. Modern United States Artillery. VII. Ill. (E–April 29.) 1400 w.

†4018. The Development of American Armor-Plate. I. Ill. F. Lynwood Garrison (J F I–May.) 5600 w.

4073. Torpedo Vessel for the United States Navy. Ill. (E N–May 12.) 1300 w.

*4122. Electricity as Applied to Torpedoes and other Naval Purposes. F. T. Hamilton (E E L–May 6.) 1900 w.

*4159. Modern United States Artillery. VIII. Ill. (E–May 6.) 1300 w.

*4303. Modern United States Artillery. IX. Ill (E–May 13.) 2200 w.

*4306. The Value of the Torpedo Boat. Editorial (Ibid.) 2700 w.

*4322. The Duke of Cambridge on War Material. Editorial (Eng L–May 13.) 1750 w.

4372. Making Projectiles for the Government. Ill. (Misc.) 2300 w.

*4394. Note sur la Puissance des Canons à Tir Rapide. P. M. V. (G C–May 14.) 2000 w.

*4466. Modern United States Artillery. X. Ill. (E–May 20.) 2100 w.

*4467. Canet v. Krupp. I. "A French Artillerist" (Ibid.) 2100 w.

*4596. Tables Numériques Fournissant Toutes les Données Relatives à la Perforation des Plaques de Blindages en Fer Barèmes Anglais, Calculés par le Capitaine Tressider. L. Baclé (G C–May 21.) 800 w.

*4648. Modern United States Artillery. XI. Ill. (E–May 27.) 2000 w.

†4732. The Development of American Armor-Plate. II. Ill. F. Lynwood Garrison (J F I–June.) 10,000 w.

*4833. Canet v. Krupp. II. "A French Artillerist" (E–June 3.) 2700 w.

MINING.

*3371. Creede, a New Mining Camp. Ill. Albert Williams, Jr. (E Mag–June.) 3000 w.

*3375. Practical Work at a Mining School. E. S. Cranson (Ibid.) 3000 w.

*3386 Présence d'Insectes Empâtés dans les Minerais de Nickel "Garniérites" de la Nouvelle-Calédonie. Jules Garnier (G C–April 2.) 900 w.

*3451. The Nottinghamshire Coalfield. Clifton Colliery. (C G–April 8.) 3200 w.

*3452. An Improved Apparatus for Ascertaining the Sensitiveness of Safety-Lamps When Used for Gas-Testing. Ill. Dr. Clowes (Ibid.) 3700 w.

3455. Early History of the Industry of Phosphate of Lime. Wm. P. Black (M S R–April 14.) 700 w.

3456. Note on Sampling Iron Ore. E. K. Landis (Ibid.) 750 w.

3465. A Neglected Corner of Arizona. (M I T–April 14.) 1800 w.

3466. La Gardette: The History of a French Gold Mine. (Ibid.) 3600 w.

3485. The Manufacture of Sulphuric Acid from Brimstone and Pyrites at Atlanta, Ga. N. P. Pratt (E M J–April 16.) 2600 w.

3486. Failures in Boomed Towns. Sheffield, Ala. (Ibid.) 1100 w.

3487. The Gold and Platinum Industry of the Ural (Ibid.) 1300 w.

3488. The Mining Law of Ontario, Canada, of 1892. A. Blue (Ibid.) 1100 w.

3493. The Present Limitations of Electric Power in Mining. II. Ill. Irving Hale (E W–April 23.) 4300 w.

3504. Feldspar. George O. Simmons (Min–April.) 5200 w.

*3513. The Electrolytic Separation of Metals (C T J–April 9.) 600 w.

3514. Early Hydraulic Mining. Wm. A. Begole (M S P–April 16.) 2100 w.

3515. Machinery for Sizing Coal. Ill. (Ibid.) 1150 w.

*3518. Phosphate Mining. Editorial (I E–March 19.) 800 w.

3580. Richness of Early Placer Mines in California. S. S. Boynton (E M J–April 23.) 1100 w.

3581. The Mining District of Oruro, Bolivia. Ill. Otto F. Pfordte (Ibid.) 2100 w.

3582. Decision of the Supreme Court in the South Carolina Phosphate Case. (Ibid.) 3700 w.

3583. The Condition of Gold in Pyrite. Albert Williams (Ibid.) 1200 w.

3586. The Diamond Fields of India. A. Mervyn Smith (Ibid.) 1400 w.

3593. Valuable Experiments in Vein-Formation. Theo. B. Comstock (Sc–April 15.) 1800 w.

*3633. Mines Surveys I. F. Jno. Franklin (C G–April 14.) 2800 w.

†3642. Nouveaux Wagonets des Charbonnages du Centre de Gilly. Vanhassel (R U M–March.) 1800 w.

3646. Mining and Competition. Editorial (M I T–April 21.) 1400 w.

3710. What is a Mineral? R. W. R. (E M J–April 30.) 950 w.

3711. Faulting in Veins. John A. Church (Ibid.) 1500 w.

3713. Hoepfner's Electrolytic Copper Process. Ill. Karl Eilers (Ibid.) 1700 w.

3714. The Determination of Lead, Silver and Zinc in Ores Composed of Galena and Blende. Emile Aubin (Ibid.) 750 w.

3715. The Elizabethton (Tenn.) Co-operative Town Bubble. Edmund C. Pechin (Ibid.) 4000 w.

3716. The Nickel Deposits of North Carolina. Stephen H. Emmons (Ibid.) 2900 w.

3720. The Gold Mines of the South. "A Mining Engineer" (M R–April 29.) 2000 w.

3722. Florida Soft Phosphate Trade. A. H. Agnew (Ibid.) 800 w.

3723. Handling Hard Rock Phosphate at Fernandina, Fla. J. H. Jones (Ibid.) 900 w.

*3761. Sur le Sondage Profond de Schladebach. Charles Zundel (M I–April 19.) 1700 w.

3827. Kansas Salt. H. C. Hovey (Misc.) 1100 w.

3834. Mock Gold. Henry G. Hanks (M S P–April 30.) 700 w.

*3836. Iron and Coal Mining in India. "An ex-Engineer" (I E–April 2.) 1000 w.

3893. Notes Upon American Iron Ore Deposits. John Birkinbine (M R–May 6.) 2200 w.

3894. Economy in the Iron and Coal Industries. Editorial (Ibid.) 1050 w.

*3931. Mining in Russia. A. Raffalovich (I–April 22.) 1000 w.

*3936. Deep Boring at Schladebach, Prussia. J. W. P. (C G–April 22.) 1100 w.

*3937. The Practical Working of Coal-Cutting Machines. Richard Sutcliffe (Ibid.) 1200 w.

*3938. Foreign Ores for the British Pig-Iron Industry (Ibid.) 1400 w.

3962. Quantity of Refuse in Anthracite Coal Beds. William Griffith (E M J–May 7.) 800 w.

3965. The Present Formation of Phosphatic Concretions in Deep-Sea Deposits. Walter B. M. Davidson (Ibid.) 1000 w.

3975. The Ore Deposits of Newman Hill. John B. Farish (M I T–May 5.) 3700 w.

*3977. The Micas. George P. Merrill (S–May.) 900 w.

*3980. Slate in Vermont. Burton H. Allbee (Ibid.) 900 w.

*3999. The Iron and Mining Industry of Austria (C G–April 29.) 1400 w.

*4000. Mines Surveys. II. F. Jno. Franklin (C G–April 21.) 900 w.

*4001. Mines Surveys. III. F. Jno. Franklin (C G–April 29.)

†4050. Mining Machinery and Appliances. John McNeil (Misc.) 3400 w.

†4051. Underground Surveying. J. S. Luckraft (Misc.) 950 w.

†4053. Steel. J. W. Nesmith (Misc.) 1900 w.

†4054. Rock Excavation. Thomas Withers (Misc.) 900 w.

4101. The Coal Fields of Montana. I. Ill. Walter Harvey Weed (E M J–May 14.) 3600 w.

4103. Accuracy of Batea-Washing. Charles Bullman (Ibid.) 1350 w.

4109. Mount Mica. Charles E. Waterman (Min–May.) 1100 w.

*4153. The Economic Geology of Copper. Ill. I. H. A. Wheeler (C E–May.) 4000 w.

*4154. Tabular Estimate Showing the Approximate Quantity, Past and Future Production of Coal in the Several Districts of the Northern Anthracite Coal Basin of Pennsylvania. Wm. Griffith (Ibid.) 5000 w.

*4156. What is a "Miner"? Editorial (Ibid.) 600 w.

4182. Cripple Creek Gold. Ill. (M I T–May 12.) 1100 w.

4216. A New System of Ore Sampling. Ill. (F & M R–May 14.) 1000 w.

4276. Carbon Deposits in Fire Brick. A. D. Elbers (E M J–May 21.) 650 w.

4277. The Coal Fields of Montana. II. Ill. Walter Harvey Weed (Ibid.) 2300 w.

4279. The Mines on Battle Mountain, Eagle County, Colo. Ill. Leo von Rosenberg (Ibid.) 800 w.

4280. A Contribution to the Geology of the Dakota Tin Mines. Titus Ulke (Ibid.) 700 w.

4281. Faulting in Veins. S. F. Emmons (Ibid.) 3800 w.

*4367. The Working of Iron Mines in Different Countries (C G–May 13.) 2400 w.

*4368. Ignition of Mine Shots. (Ibid.) 2500 w.

*4369. Mines Surveys. III. Ill. F. Jno. Franklin (Ibid.) 2000 w.

4380. Progress of Mining in China. Ill. (M S P–May 21.) 1500 w.

†4388. Note sur le Rallumage des Lampes de Sureté dans les Mines. Ill. Joseph Goffin (R U M–April.) 2600 w.

†4389. Note sur la Machine à Façonner les Bois des Charbonnages de Sars-Longchamps et Bouvy. Ill. Alfred Mathieu (Ibid.) 550 w.

4414. Tennessee's Need of a Geological Survey. Wm. M. Bowron (M R–May 27.) 1400 w.

4416. Llano's Mineral Region. Thomas P. Grasty (Ibid.) 1000 w.

*4443 Explosions de Grisou et d'Hilarité. "El" (M I–May 17.) 1900 w.

4452. Memoir of Manganese Mines, Ponupo Group. Ill. (A M & I W–May 27.) 2000 w.

4454. Faulting in Veins. L. D. Ricketts (E M J–May 28.) 1500 w.

4455. The Construction and Use of the Dipping Needle. D. T. Marshall (Ibid.) 1100 w.

4456. The Mines of Cripple Creek. Ill. (Ibid.) 3000 w.

4457. Accidents in Mines. An English Mining Engineer (Ibid.) 3100 w.

4459. Failures in Boomed Towns: Florence, Ala. H. S. Fleming (Ibid.) 1300 w.

*4515. The Iron and Coal Industries of the Continent in 1894. Review of the year. Wilhelm v. Lindheim, Victor Watteyne, Francis Laur, Max Diezmann, and J. Walter Pearse (I–May 20.) 13,000 w.

*4522. Mines Surveys. Ill. IV. F. Jno. Franklin (C G–May 20.) 2600 w.

*4523. The Iron Ores of Nova Scotia. E. Gilpin, Jr. (Ibid.) 1250 w.

*4528. Russian Mining Law. (Ibid.) 1100 w.

*4529. Tipping Ore Trucks. Ill. (Ibid.) 700 w.

*4530. The Ventilation of Fiery Mines. M. Rateau. (Ibid.) 2400 w.

†4536. Mining Engineering. Ill. John L. Culley (J A E S–April.) 4500 w.

*4589. Une Prétendue Contribution à l'Etude de l'Atmosphère des Houillières. "El" (M I–May 24.) 850 w.

4602. The Origin of Coal and Petroleum. A. E. Forstall (P A–June 1.) 3760 w.

4628. Varley's Electric Divining Rod. R. W. R. (E M J–June 4.) 800 w.

4629. Zinc-Blende Mining near Webb City, Mo. Ill. Carl Heinrich (Ibid.) 700 w.

4630. The Mines and Mills in Pribram in Bohemia. John W. Meier (Ibid.) 1500 w.

4631. Tin Mining in the United States. Ira Ayer (Met W–June 4.) 2700 w.

4637. San Miguel Co., Colorado. Ill. C. L. Hall (E & M R–June 4.) 4400 w.

*4660. Electricity as Applied to Mining Operations. E. H Booth (I S E–June.) 2800 w.

*4684. Electricity at the Belmont and Sheridan Mines, Telluride, Colorado Ill. C. A. P. Waters (E E N Y–June 8.) 950 w.

*4703. Proposed General System of Draining Cleveland Ironstone Mines. A. L. Steavenson (C G–May 27.) 4200 w.

*4704. Sinking Operations in Warwickshire. (Ibid.) 1600 w.

*4706. The Leicestershire Coal field. M. E. (Ibid.) 2700 w.

*4707. Mines Surveys. Ill. V. F. Jno. Franklin (Ibid.) 800 w.

*4708. The Coalfield of the Cape. (Ibid.) 1200 w.

*4709. The Austrian Firedamp Commission. W. N. Atkinson (Ibid.) 2100 w.

4766. Coal Resources of the West Virginia Central and Pittsburg Railway. Ill. (M R–June 10.) 3100 w.

4774. The Decadence of Nevada as a Mining State. Editorial (E M J–June 11.) 700 w.

4775. Faulting in Veins. I. John A. Church (Ibid.) 2100 w.

4778. The Tricks of Miners. Dan de Quille (Ibid.) 2700 w.

4779. On the Best Form of Safety Fuses. (Ibid.) 1400 w.

4810. Civilizing Influence of Mining. Editorial (M I T–June 9.) 1100 w.

†4817. Prof. I. C. White's "Stratigraphy of the Bituminous Coal Field of Pennsylvania, Ohio and West Virginia." John J. Stevenson (A G–June.) 1400 w.

†4818. Gold in Placers. Ill. Herbert R. Wood. (Ibid.) 2100 w.

*4827. A New Coal-Cleaning Plant at a Scotch Colliery (C G–June 3.) 1200 w.

*4828. Mines Surveys. VI. Ill. F. Jno. Franklin (Ibid.) 500 w.

*4848. The Gold-Fields of South Africa. II. Ill. Gustave Hallé (E Mag–July.) 3000 w.

PHOTOGRAPHY.

3446. Collodio-Silver Chloride Printing-Out Process. P. C. Duchochois (P T–April 15.) 1400 w.

3447. The Chemistry of Photography. VIII. W. Jerome Harrison (Ibid.) 1400 w.

*3448. Notes on Popular and New Heliographic Processes. Ill. B. H. Thwaite (M W–April 8.) 2300 w.

*3525. Stereoscopic Pictures Without a Stereoscopic Camera. Editorial (B J P–April 8.) 750 w.

*3526. Photographing on Wood. Editorial (Ibid.) 1400 w.

*3527. Can Silver Prints be Made Permanent? Editorial (Ibid.) 950 w.

*3528. Photographing on Wood for Engraving Purposes. Ill. W. J. Rawlings (Ibid.) 900 w.

*3529. Electric Lighting in Photography. Henry Van Der Weyde (Ibid.) 1600 w.

*3530. The Wet-Collodion Process. Thos. Forrest (Ibid.) 2500 w.

3594. Experiments with Para-Amidophenol (P T–April 22.) 1000 w.

3595. The Chemistry of Photography. IX. W. Jerome Harrison (Ibid.) 1500 w.

3596. Mr. Ives's Polychromatic Lantern Slides (A P B–April 23.) 1000 w.

3597. Blisters or No Blisters. F. E. Payne (Ibid.) 1200 w.

*3625. Photography and Photo-Mechanical Printing. Paul L. Waterlow (Inv–April 16.) 3000 w.

*3637. The Early Days of Animal Photography. Frank Haes (B J P–April 15.) 1800 w.

*3638. Development of Insufficiently Printed Proofs of Celloidin, Oberretter, Aristo, Mignon, and Similarly Prepared Papers. E. Valenta (Ibid.) 1500 w.

*3639. Optical Projection. G. R. Baker (Ibid.) 1300 w.

*3640. Photo-Micrographs in the Lantern. T. E. Freshwater (Ibid.) 1000 w.

*3669. Procédé Photographique Aux Sels Manganiques. I. (M P–April 15.) 750 w.

*3846. The Permanency of Photo-Mechanical Reproductions. Julius F. Sachse (A J P–May.) 1400 w.

*3847. The Wet Collodion Plates. II. Ellerslie Wallace (Ibid.) 1400 w.

*3848. Platinum Toning as Applied to Gelatino-Chloride Printing-Out Paper. James Brown (Ibid.) 1800 w.

*3849 Platinum Toning on Matt-Surface Paper. T. O. Mawson (Ibid.) 1200 w.

*3850. Uranium Toning of Bromide Prints. J. Weir Brown (Ibid.) 4000 w.

3889. The Chemistry of Photography. X. W. Jerome Harrison (P T–April 29.) 1500 w.

*3884. The Debt of Art-Photography to Science. Editorial (B J P–April 22.) 1100 w.

*3885. Recovering Silver from Spoilt Plates. Editorial (Ibid.) 2300 w.

*3886. Ratio of Gradation. H. J. Channon (Ibid.) 2750 w.

*3887. On Some Points Relating to Development and to the Formation of the Latent Image. C. H. Bothamley (Ibid.) 2000 w.

*3888. Photography Applied to Medical Research. Andrew Pringle (Ibid.) 2400 w.

*3889. Stereoscopic Photography. E. J. Appleby (Ibid.) 2000 w.

*3890. Photography and the Detection of Crime. "Lex" (Ibid.) 900 w.

3908. Meta-Gelatine. P. C. D. (P T–May 6.) 800 w.

3909. Kallitype No. 2. P. C. Duchochois (Ibid.) 900 w.

3910. The New Jena Glass Lenses. W. J. Stillman (Ibid.) 800 w.

3911. Method for Increasing the Sensitiveness of Asphaltum to Light. P. C. D. (Ibid.) 1500 w.

3912. Oxide of Zinc in Zincography. F. Santner (Ibid.) 700 w.

3913. Notes on Some New Rapid Ortho-Chromatic Collodio-Bromide Processes. I. J. Waterhouse (Ibid.) 1100 w.

*3981. The New Concentric Lens. Editorial (B J P–April 29.) 1050 w.

*3982. Development of Partly Printed Proofs, Lantern Slides and Opals. Editorial (Ibid.) 900 w.

*3984. Development of Weakly Printed Positives on Glass and Opal. E. Valenta (Ibid.) 1000 w.

*3985 Lantern Slides: How to Produce and Exhibit them. Fred. Dunsterville (Ibid.) 3800 w.

†3986. View Photography. I. R. W. Harrison (W P M–May 7.) 1650 w.

†3987. The Distortion Caused by Abuse of Wide-Angle Lenses. C. A. Hubback (Ibid.) 650 w.

†3988. Artificial Lighting in Photography. H. Van Der Weyde (Ibid.) 1750 w.

4093. The Causes of Fading. I. P. C. Duchochois (P T–May 13.) 500 w.

4094. The Keeping Qualities of Plates. H. Edwards-Ficken (Ibid.) 650 w.

4095. The Prevention of Halation. W. K. Burton (Ibid.) 1500 w.

4096. Heliochromy. C. E. (Ibid.) 900 w.

4097. Notes on Some New Rapid Ortho-Chromatic Collodio-Bromide Emulsion Processes. II. J. Waterhouse (Ibid.) 1100 w.

*4138. Platinotype Modifications. Editorial (B J P–May 6.) 1100 w.

*4139. The Employment of Stops in Landscape Work. Editorial (Ibid.) 1900 w.

*4140. Obsolete Processes. I. The Daguerreotype (Ibid.) 1400 w.

*4141. Collodion Emulsion Notes. I. W. B. Bolton (Ibid.) 1400 w.

*4142. Bromide Enlarging. Frederick Park (Ibid.) 2800 w.

*4143. The Present Position of Photography in Relation to Book and Periodical Illustration. I. Tom Symmons (Ibid.) 2700 w.

4179. Hints on Mounting Photographs. (A P B–May 14.) 1600 w.

4180. About Lichtdruck. I. Adolf Beyersdorff (Ibid.) 2300 w.

4181. Gas Cylinders and their Safety. F. A. Bridge (Ibid.) 2500 w.

*4291. Extemporized Hand Cameras. W. Miles Barnes (Inv–May 14.) 1100 w.

*4292. Stereoscopic Photography. E. J. Appleby (Ibid.) 2500 w.

*4326. The Keeping Properties of Rollable Celluloid Films. Editorial (B J P–May 13.) 700 w.

*4327. Celluloid Emulsion Notes. W. B. Bolton (Ibid.) 1200 w.

*4328. The Wet Collodion Process. J. Barker (Ibid.) 1000 w.

*4329. Chrono-Photography of Star Transits. John Harmer (Ibid.) 1400 w.

*4330. The Present Position of Photography in Relation to Book and Periodical Illustration. II. Tom Symmons (Ibid.) 2400 w.

*4331. Photography in Natural Colors. Dr. H. W. Vogel (Ibid.) 600 w.

*4332. Depth of Focus: The Concentric Lens. F. H. Wenham (Ibid.) 900 w.

*4333. The Concentric Lens. W. J. Stillman (Ibid.) 550 w.

†4357. The Easiest Method of Aristotype Printing. John A. Tennant (W P M–May 21.) 1000 w.

†4358. Distortion of Outline in Photography. Chapman Jones (Ibid.) 3800 w.

†4359. Photography Without a Lens. G. H. Niewenglowski (Ibid.) 1200 w.

†4360. Panoramic Photography. (Ibid.) 1100 w.

†4361. View Photography. II. R. W. Harrison (Ibid.) 1500 w.

*4378. Sur l'Emploi des Plaques Orthochromatiques pour la Carte Photographique du Ciel. N. C. Duner and Léon Vidal (M P–May 15.) 1500 w.

4381. The Causes of Fading. II. P. C. Duchochois (P T–May 20.) 2100 w.

4382. Notes on Some New Rapid Orthochromatic Collodio-Bromide Emulsion Process. III. J. Waterhouse (Ibid.) 1250 w.

*4516. A Question of Exposure. Editorial (B J P–May 20.) 1800 w.

*4517. Obsolete Processes. II. The Calotype (Ibid.) 1300 w.

*4518. A New Formula for the Dusting-on Process. W. B. Bolton (Ibid.) 1300 w.

*4519. Advanced Photographic Work for Amateurs. I T. N. Armstrong (Ibid.) 1300 w.

4544. Glass Positives. Ellerslie Wallace (A P B–May 28.) 2500 w.

4545. The Development of Printing-Out Papers. Alex. Lainer (Ibid.) 1900 w.

4546. About Lichtdruck. II. Adolf Beyersdorff (Ibid.) 1300 w.

4547. The Use of the Watkins Exposure Meter. Edwin J. Prindle (Ibid.) 950 w.

4548. On the Recovery of Gold and Silver by a New Method. Editorial (P T–May 27.) 900 w.

4549. Some Advice on the Rapid Lighting with Magnesium. "D" (Ibid.) 1600 w.

*4666. Composite Heliochromy. III. F. E. Ives (Misc.) 5800 w.

4696. The Preservation of Modern Prints. Editorial (B J P–May 27.) 1350 w.

*4697. Photography in Military Reconnaissance. G. R. Baker (Ibid.) 1500 w.

*4698. Fixation of Silver Prints. Lyonel Clark (Ibid.) 1400 w.

*4699. Ratio of Gradation. H. J. Channon (Ibid.) 1600 w.

*4700. Projections in Natural Colors. Albert W. Scott (Ibid.) 1000 w.

*4701. Gelatino-Chloride-of-Silver: Its Manipulation. I. J. C. S. Mummery (Ibid.) 2700 w.

*4736. The Proper Manipulation of Perfected Aristo Paper. Louis Bradfisch (W P M June 4.) 650 w.

4737. Photographing on Hard Surfaces (P T–June 3.) 900 w.

*4740. Early Daguerreotype Days. I. III. Julius F. Sachse (A J P–June.) 3000 w.

*4741. The Wet Collodion Plates. III. Ellerslie Wallace (Ibid.) 1400 w.

4789. Schools of Photography. Charles Ehrmann P T–June 10.) 900 w.

4790. Quick Shutters. W. J. Stillman (Ibid.) 600 w.

4791. Art: Its Relation to Photography. B. F. McManus (Ibid) 850 w.

4792. On Corrections of Distortions, and Their Relation to Perspective in Photography. I. (Ibid.) 2900 w.

4807. About Lichtdruck. III. Adolf Beyersdorff (A P B–June 11.) 1800 w.

4808. On Chemigraphic Etching. Leon Warnerke (Ibid.) 2400 w.

4809. Positives in Blue (Cyanotypes). Abe Lizzard (Ibid.) 2000 w.

*4825. Do Negatives Fade? Editorial (B J P–June 3.) 850 w.

*4826. Gelatino-Chloride-of-Silver Paper: Its Manipulation. II. J. C. S. Mummery (Ibid.) 3300 w.

RAILROADING.

*3376. The Railroads and Wall Street. Thos. L. Greene (E Mag–June.) 3000 w.

3389. Extended Smokeboxes on Compound Locomotives. J. Snowden Bell (R G–April 15.) 1300 w.

3390. Compulsory Legislation on Safety Appliances. H. S. Haines (Ibid.) 2900 w.

3391. Power Necessary to Haul Trains up Various Grades. (Ibid.) 800 w.

3392. The City and South London Electric Railroad. W. H. Booth (Ibid.) 1300 w.

3393. White Lights Dangerous for Signals. Editorial (Ibid.) 2400 w.

3394. Acceleration and Retardation of Suburban Trains. Ill. Editorial (Ibid.) 900 w.

3395. Books on Railroading. I. (Ibid.) 1100 w.

3411. Report of Committee on Discrimination Arising from the Use of Private Cars of Shippers (R R–April 16.) 6500 p.

3412. Railroad Signals and Switches. IV. Ill. James F. Hobart (Ibid.) 2900 w.

3414. Japanese Railways (Ibid.) 1600 w.

3415. Coaches on Indian Railways. Ill. (Ibid.) 1000 w.

3416. Private Cars and Their Abuses. Editorial (Ibid.) 1200 w.

*3418. Sur l'Application de l'Electricité à la Traction des Tramways et des Chemins de Fer. I. (Misc.) 2800 w.

*3420. Sur l'Application de l'Electricité à la Traction des Tramways et des Chemins de Fer. II. (Misc.) 3500 w.

3423. Shall Street Railways Build Their Own Cars? (Misc.) 2600 w.

3424. Tramway Regulations in Europe. (Misc.) 1200 w.

*3433. Railway Extension in New South Wales. Ill. (Eng L–April 8.) 1200 w.

*3437. The Oscillation of Railway Carriages. C. E. Cardew (Ibid.) 1300 w.

†3458. British East Africa and the Mombasa Railway. George S. Mackenzie (F R–April.) 7500 w.

*3469. River Steamers for Indian Railways. II. Ill. Seymour B. Tritton (I L–April 8.) 1500 w.

3489. Dewey's Electric Railway System. Ill. (E R N Y–April 23.) 950 w.

3503. Maintenance of Way. II. M. J. MacInarna (R A–April 15.) 1300 w.

*3520. Railway Economics. "A Railway Engineer" (I E–March 19.) 800 w.

*3534. An Inclined Cable Railway for Transferring Freight Cars Between the Upper and Lower Yards of the Western Cable Railway Co., St. Louis. Ill. Edw. Flad (J A E S–Feb.) 5000 w.

3538. The Trolley for Chicago. Editorial (S R G–April 16.) 1800 w.

†3546. But et Organisation des Chemins de Fer Vicinaux. Ill. Léon Petit (R U M–Feb.) 7500 w.

3564. The History of the Equalizing Lever and the Development of the "American Type" of Locomotive. Ill. E. P. Eastwick (R G–April 22.) 3100 w.

3566. Riveting Locomotive Boilers. Editorial. (Ibid.) 900 w.

3567. Books on Railroading. II. (Ibid.) 1300 w.

*3591. Chemin de Fer a Vitesses Multiples ou Trottoirs Mobiles. Ill. Ernest Pontzen (G C–April 9.) 3500 w.

*3599. Rapid Transit in Cities. I. The Problem. Ill. Thomas Curtis Clark (Misc.) 6500 w.

3605. Railroad Signals and Switches. V. Ill. James F. Hobart (R R–April 23.) 3000 w.

3606. Uniformity of Railway Accounting. Wm. O. Seymour. Isaac N. Phillips and Isaac B. Brown (Ibid.) 4000 w.

3617. Electricity upon Steam Railroads. A. T. Starkey (E & R–April.) 1500 w.

3652. Methods of Electrically Controlling Street Car Motors. Ill. H. F. Parshall (E R N Y–April 30.) 4200 w.

3653. The Grain of Sand on the Track. (Ibid.) 1100 w.

3656. A Comparative Test of High and Low Speed Engines for Use in Electric Railway Power Plants. Chas. W. Wason (E W–April 30.) 900 w.

3673. Causes of Rail Breakages. Ill. W. R. Hinsdale (Misc.) 2300 w.

3676. Efficiency of Locomotives. Ill. J. J. Flather (A M–April 28.) 1100 w.

*3683. Triple-Expansion Locomotives. Editorial (L E–May.) 750 w.

*3684. When Does it Pay to Destroy a Locomotive? A. Dolbeer (Ibid.) 1200 w.

3686. American Type of Freight-Cars for Foreign Railways. (E N–April 28.) 2800 w.

3698. French and German Street Car Service. J. M. Batchelor (E A–April 30.) 1200 w.

3706. New Developments and Renewed Hopes for the Storage Battery Street Car Propulsion. J. K. Pumpelly (W E–April 30.) 1000 w.

3726. Locomotive Comparisons. "Justice" (R G–April 29.) 750 w.

3727. Block Signaling Apparatus on the Chicago, Milwaukee & St. Paul. Ill. (Ibid.) 800 w.

3728. The "Triple Fish" Rail Joint. Ill. (Ibid.) 950 w.

3729. Freight Trucks and Brake Beams. Editorial (Ibid.) 1000 w.

3730. Grain Transportation in Russia. I. Editorial (Ibid.) 2300 w.

3759. Railway Ticket Scalping. "Squire" (R A–April 29.) 2100 w.

*3760. Les Locomotives Compound. "El" (M I–April 19.) 1300 w.

3765. Continuous Platforms, Vestibules and Vertical Plane Couplers for Passenger Cars. Editorial (R R–April 30.) 1100 w.

3766. Boston Differentials. Decision of the Inter-State Commerce Commission (Ibid.) 3500 w.

3767. Thomas Steel for Rails (A M & I W–April 29.) 700 w.

3774. Improvements Needed on Railways. Editorial (R C J–April.) 350 w.

3775. Car Ventilation. Ill. A. R. Townshend (Ibid.) 1000 w.

3782. A Scrap of Chinese Railroad History (M N–May 1.) 400 w.

*3795. Some Baltimore & Ohio History (R A E J–May.) 2500 w.

*3796. Sampling and the Enforcement of Specifications. I. C. B. Dudley and F. N. Pease (Ibid.) 4500 w.

*3797. A Discussion of the Possibilities of the M. C. B. Coupler. Ill. II. Edward P. Eastwick, Jr. (Ibid.) 3500 w.

*3799. Three-Rail Turnouts for Double-Gauge Tracks. I. Ill. James K. Geddes (Ibid.) 2500 w.

3809. A New Hydraulic Clutch. Ill. F. M. Barney (E R N Y–May 7.) 750 w.

3818. Electric Railway Pole Line Construction. I. W. F. D. Crane (E E N Y–May 4.) 750 w.

*3821. English and American Locomotives. "An Indian Locomotive Superintendent" (Eng L–April 22.) 1100 w.

*3823. A Sumatrian Railway. Ill. (Ibid.) 2200 w.

3832. Application of Electricity to Railways (S R G–April 30.) 1500 w.

*3843. The Development of Gas Lighting in Railway Trains. Ill. E. C. Riley (J G L–April 26.) 3900 w.

*3853. Trains Continus et Trottoirs à Vitesses Multiples. Eugène Henard (G C–April 23.) 1000 w.

*3855. Rappel à Ressort pour Signaux de Chemins de Fer. Ill. G. Petit (Ibid.) 700 w.

†3856. Consular Reports on Local Transportation in European Cities (Misc.) 4500 w.

†3858. Car Builder vs. Car Buyer: What is the Proper Relation Between Them? "B" (Misc.) 1000 w.

3861. Car Interchange at Chicago. Editorial (R M M–May.) 1100 w.

3862. Compulsory Legislation on Railway Safety Appliances. Editorial (Ibid.) 1800 w.

3863. Uniformity in Coupler Unlocking-Devices. Editorial (Ibid.) 1200 w.

*3877. The Electric Railway in the Salt Works at Neu-Stassfurt (E R L–April 22.) 2400 w.

3903. The Grade Crossing Problem in Buffalo. Ill. Edward B. Guthrie (R G–May 6.) 2600 w.

3904. The American and the English Locomotive. Editorial (Ibid.) 3100 w.

3905. Grain Transportation in Russia. II. Editorial (Ibid.) 2600 w.

3906. Books About Railroading. III. (Ibid.) 1250 w.

3907. Safety Chains Between Engines and Tenders. A. T. Woods (Ibid.) 1250 w.

†3915. Siam's First Electric Railway (Misc.) 1300 w.

*3928. Bearing-Metal Alloys. I. C. B. Dudley (I–April 22) 4100 w.

3939. Railway Cars in Russia (R C J–May.) 1600 w.

3944. Sir James Allport. Editorial (Eng L–April 29.) 2000 w.

*3991. Bearing-Metal Alloys. II. C. B. Dudley (I–April 29.) 3500 w.

*3996. American and British Railroad Results. Editorial (E–April 29.) 1900 w.

*4005. Nouvelle Locomotive Express de la Cie des Chemins de Fer de l'Est. Ill. El. (MI–April 26.) 2200 w.

4028. Starting Electric Cars (S E–May 7.) 800 w.

4031. Metal Ties on Indian Railways. "Railroader" (R R–May 7.) 2400 w.

4032. Reasonable Rates. Committee report (Ibid.) 4000 w.

†4049. Tramway Permanent Way. II. James More, Jr. (Misc.) 4000 w.

†4060. The Application of the "Abt System" to Mountain Railways. W. B. Lawson (Misc.) 4900 w.

4075. Coupler Breakages. Ill. (E N–May 12.) 1500 w.

4144. Breakages of Janney Couplers. Ill. (R A–May 13.)

4146. Private Freight Cars. John R. Wheeler (Ibid.) 5200 w.

†4148. A Parliamentary View of the Victoria Nyanza Railway. Ill. Richard Temple (F R–May.) 5100 w.

*4158. Formosa and Its Railways. II. (E–May 6.) 1300 w.

4170. The Interstate Commerce Commission's Statistical Report as Seen Through English Spectacles. W. M. Acworth (R R–May 14.) 2000 w.

4171. The Pennell Water Purifier. Ill. (Ibid.) 900 w.

4183. Leavenworth's Compressed Air Hopes. Ill. (Misc.) 1600 w.

4212. Air Brakes on Mountain Grades. Paul Synnestvedt (R G–May 13.) 950 w.

4213. Color and Form for Night Signals. C. A. Hammond (Ibid.) 2000 w.

4214. The Standard Code on the Southern Pacific. (Ibid.) 1900 w.

4215. The Union Pacific and Its Growth. Editorial (Ibid.) 2400 w.

4222. Electric Railway Pole-Line Construction. II. W. F. D. Crane (E E N Y–May 18.) 1100 w.

4234. Starting Electric Cars (S R G–May 14.) 800 w.

4247. Progress in Steel Car Construction (E N–May 19.) 1000 w.

4252. The Pros and Cons of Iron Car Construction. Editorial (Ibid.) 2000 w.

4271. To Avoid Running Past Red Lights. R. C. E. (R G–May 20.) 1150 w.

4272. Freight Yards. Ill. A. Morrison (Ibid.) 1400 w.

4294. Railroad Signals and Switches. VI. Ill. James F. Hobart (R R–May 21.) 2500 w.

4295. Differential Rates. James L. Cowles (Ibid.) 2500 w.

4297. Coaling Station and Sand House. Ill. (Ibid.) 1100 w.

4299. The Genesis of New England Railroads. Frank H. Forbes (Ibid.) 4200 w.

4301. Fire Test of a Carburetor at Pullman. Ill. (Ibid.) 650 w.

*4302. Formosa and Its Railways. I. Ill. (E–May 13.) 2600 w.

*4304. Locomotive Performances in New South Wales (Ibid.) 1500 w.

*4318. The Conversion of Gauge on the Great Western Railway. Ill. I. (Eng L–May 13.) 3900 w.

4340. Electric Locomotives for Short Steam Roads. Editorial (E E N Y–May 25.) 1000 w.

4344. Test of the Neversink Mountain Electric Road. Ill. H. S. Hering and Wm. S. Aldrich (E W–May 28.) 1400 w.

4345. The First Elevated Electrical Railroad. Ill. Guy B. Waite (Ibid.) 900 w.

†4352. The Slaughter of Railway Employees. Henry C. Adams (F–June.) 2700 w.

†4386. Note sur la Durée Moyenne des Tuyaux de Raccord en Caoutchouc pour le Chauffage des Trains à l'Eau Chaude. E. Belleroche (R U M–April.) 500 w.

4396. Electric Street Railways. T. C. Martin and H. M. Whitney. (S R N–May 28.) 4100 w.

4398. The Railway Problem in Chicago. Editorial (S R G–May 21.) 3800 w.

4405. A Proposed Rapid Transit System for Montreal. Ill. H. W. Wicksteed (E N–May 26.) 1000 w.

4406. Standard Buildings on the Macon & Birmingham R. R. Ill. (Ibid.) 300 w.

4407. Screw Piles in Germany. Ill. (Ibid.) 650 w.

4408. Ship Railways in Europe. A. H. Duthil (Ibid.) 650 w.

*4458. The Zone Tariff System of Herr Gabriel Von Baross. Ill. Joseph Körösi (Misc.) 2300 w.

4441. Easement Curves. C. Frank Allen (R G–May 27.) 700 w.

4448. Maintenance of Way, Eastern Railroad of France (Ibid.) 1500 w.

*4476. Electric Railways in London (E–May 20.) 1600 w.

*4478. The Use of Timber on Western Railroads, U. S. A. Ill. (Ibid.) 1100 w.

*4481. Traction. E. T. Carter (El–May 20.) 1000 w.

*4485. The Bradford Electrical Tramcar. Ill. (Ibid.) 700 w.

*4488. The Electric Railway Schemes in Parliament. Joint Committee of Lords and Commons (Ibid.) 8500 w.

*4491. The Conversion of Gauge on the Great Western Railway. II. Ill. (Eng L–May 20.) 4800 w.

4531. Relative Rates. Editorial (R R–May 28.) 1400 w.

4532. The Wholesale and Retail Principle in Railway Traffic. Editorial (Ibid.) 1000 w.

4533. The Transportation Terminal Problem in Chicago (Ibid.) 3600 w.

4534. The Continuous Reduction in Freight Charges. Horace A. Keeper (R A–May 27.) 1750 w.

*4542. Draft Gears for Freight Cars. Ill. D. L. Barnes (N C B–June.) 4400 w.

*4543. Breakage of Steel Tired Wheels on German Railroads. P. H. Griffin (Ibid.) 700 w.

†4550. Liverpool's Street Railways. J. McGhie (Misc.) 2300 w.

4566. The Relations Between Engine and Dynamo in Railway Work. Chas. Hewitt (E E N Y–June 1.) 600 w.

4570. Relative Proportions in Railway Power Plants. D. D. Book (Ibid.) 1000 w.

4573. Braking Street Cars Electrically. Maurice Hoopes (Ibid.) 600 w.

4574. Storage Batteries in Railway Power Stations. W. M. Miner (Ibid.) 450 w.

†4576. The Manufacture of Tramway Cables. (Misc.) 3100 w.

†4577. Railway Train Lighting. William Langdon (Misc.) 6100 w.

†4578. Availability of the Cañons of the Colorado River of the West for Railway Purposes. Ill. Robert Brewster Stanton, A. F. Sears, O. F. Nichols, S. M. Rowe, John Early, J. F. Le Baron, J. Foster Crowell, L. Anderson, J. Q. Barlow, and L. Kingman (Misc.) 35,000 w.

*4581. English and American Locomotives. Ill. Editorial (R A E J–June.) 5900 w.

*4582. Sampling and the Enforcement of Specifications. C. B. Dudley and F. N. Pease (Ibid.) 2500 w.

*4583. Three-Rail Turnouts for Double-Gauge Tracks. Ill. II. James K. Geddes (Ibid.) 1200 w.

4621. The Best Metal for Brake Shoes. "Durability" (R G–June 3.) 1400 w.

4623. The Woodlawn Junction of the New Haven and the Harlem Railroads. Ill. (Ibid.) 1700 w.

4624. Quick and Slow Acting Brakes. Editorial (Ibid.) 750 w.

*4647. The Glasgow Central Railway. I. Ill. (E–May 27.) 3000 w.

*4650. The New Signalling System and Alterations at Waterloo Station. Ill. (Ibid.) 2800 w.

*4651. Mixed Traffic Locomotive for the Great Eastern Railway. Ill. (Ibid.) 1400 w.

*4653. The Last of the Broad Gauge. Editorial (Ibid.) 3100 w.

*4667. The Conversion of Gauge on the Great Western Railway. III. Ill. (Eng L–May 27.) 5600 w.

*4671. Electric Locomotion in Central London (Ibid.) 2400 w.

4673. Railway Train Lighting. A. H. Bauer (E R N Y–June 11.) 8200 w.

4676. From Chicago to St. Louis by Electric Express. Ill. Wellington Adams (E W–June 11) 4200 w.

4692. Private Cars and their Attendant Evils. A. M. Simmons (R R–June 4.) 3000 w.

4694. The Railroad Problem. Joseph D. Potts (Ibid.) 3800 w.

4695. The Electric Railway as Applied to Steam Roads. Ill. J. Dashiell, Jr. (Ibid.) 2500 w.

*4720. Trucks for Electric Motor Cars. Ill. (Misc.) 6900 w.

†4731. Gibbon's Duplex Street Railway Track. Ill. (J F I–June.) 1200 w.

4749. Softening Hard Water for Locomotive Use. Ill. (E N–June 9.) 1200 w.

4750. The Railway Terminal and Harbor Problem in Chicago. Ill. (Ibid.) 2100 w.

4752. New Facts as to High Speed Train Resistance. Ill. Editorial (Ibid.) 2800 w.

4759. Abolition of the Broad Gauge on the Great Western of England. Ill. F. B. L. (R G–June 10.) 2500 w.

4761. A Chinese Freight Car Truck. Ill. (Ibid.) 900 w.

4762. Freight Yards. T. Appleton (Ibid.) 1700 w.

4763. Power Required to Haul Suburban Passenger Trains. Ill. Editorial (Ibid.) 1100 w.

4764. First Electric Mill Tramway in Chicago. Ill. (W E–June 11.) 900 w.

4806. Compound Locomotives. Principles and Operation of the Vauclain System. Ill. (R A–June 10.) 1700 w.

*4816. The Cost of Tramway Traction. J. Forrest Brunton (Eng L–June 3.) 1050 w.

4819. Railroad Signals and Switches. VII. Ill. James F. Hobart (R R–June 11.) 2800 w.

4821. Railroads as Equalizers of Commercial Conditions. Editorial (Ibid.) 1500 w.

*4829. Formosa and Its Railways. II. Ill. (E–June 3.) 3100 w.

*4830. The Glasgow Central Railway. II. Ill. (Ibid.) 3200 w.

*4832. The Last of the Broad Gauge. Ill. (Ibid.) 1600 w.

*4837. How Railroad Companies Buy Rubber Goods. I. A. Sherman (I R W–June 15.) 2600 w.

*4840. Some Lessons in Rapid Transit. Louis Heilprin (E Mag–July.) 3000 w.

SANITARY ENGINEERING.

*3370. Sanitary Progress in New York. Charles F. Wingate (E Mag–June.) 3000 w.

*3379. Warming and Ventilation of Public Buildings With or Without Motive Power. I. J. D. Sutcliffe (I C B–April 1.) 1500 w.

*3396. A Programme of Sanitation. (S R–April 1.) 1800 w.

*3397. Flushing Operations. Ill. (Ibid.) 1300 w.

†3454. Errors in Ventilation. William Henry Thayer (San–April.) 2400 w.

*3560. Sanitary Plumbing. I. Ill. Cesare J. Marani (Misc.) 2400 w.

*3611. The Sewage Farms of Berlin. H. A. Roechling (Eng L–April 15.) 1000 w.

*3670. L'Epuration des Eaux Industrielles, Système Henri Desrumaux. Ill. F. Desquiens (G C–April 16.) 4000 w.

†3746. Conservation of Filth in Chinese Cities and the Fruits Thereof. Ernest Norfleet (San–May.) 5200 w.

*3749. Methods of Collection, and the Disposal of Waste and Garbage by Cremation. W. F. Morse (A H–May.) 5600 w.

*3750. Microscopic Examination of Water from Public Water-Supply of Erie, with Remarks Thereon. David N. Dennis (Ibid.) 700 w.

*3854. Les Bains d'Ouvriers. Ill. Max de Nansouty (G C–April 23.) 1700 w.

*3940. The Pollution of the River Douglas. W. Naylor (C T J–April 30.) 2100 w.

*3945. The Drainage of Cairo. (Eng L–April 29.) 1400 w.

†3969. Some Results of Sanitary Legislation in England Since 1875. Ill. Gary N. Calkins (T Q–Dec.) 2500 w.

*3972. Milk Supply and the Public Health. Wm. T. Sedgwick (Ibid.) 5800 w.

*3989. The Blessings and Curses of Dust. O. T. Elliott (Misc.) 2500 w.

4076. The Sewerage of the District of Columbia (E N–May 12.) 2200 w.

4077. Chicago's Standing Danger of Water Pollution. Editorial (Ibid.) 2600 w.

4118. Schoolhouse Heating. F. S. Dewey (M W–May 14.) 2750 w.

4134. The Sewage Problem in Baltimore. C. W. Chancellor (P–May.) 1200 w.

4199. Water Supply and Public Health. I. Allen Hazen (A An–May 15.) 1250 w.

4253. The Sewerage Systems of the New England States. Editorial (E N–May 19.) 4060 w.

4265. Trap Venting Denounced. John Kelly (D E–May 16.) 900 w.

*4313. Electricity and Sanitation. Editorial (E E L–May 13.) 800 w.

*4316. Ventilation. Thos. Fuller (Misc.) 5600w.

†4428. Diagram for Flow in Pipe Sewers According to Kutter's Formula. Ill. Arthur N. Talbot (Misc.) 1900 w.

†4431. Manufacture of Vitrified Sewer Pipe Ill. Wm. C. Klingelhoefer (Misc.) 1700 w.

*4494. The Drainage of Cairo. Editorial (Eng L–May 20.) 800 w.

4611. Sewage Disposal of Isolated Dwellings and Institutions. W. K. Parry (E N–June 2.) 4500 w.

4612. Street Sprinkling in Boston. (Ibid.) 900 w.

4617. Disposal of House Refuse at Liverpool, England. H. P. Boulnois (Ibid.) 1300 w.

4633. The Trap in the House Drain. (B J C–June 4.) 1150 w.

4639. On the Use of Galvanized Iron for Artesian Wells and for the Conveyance of Drinking Water. Reuben Haines (M & B–May.) 3200 w.

4780. Historical Retrospect of Sanitation. T. Patrick Hehir (I E–May 7.) 1250 w.

4795. Conservation of Filth in Chinese Cities. Ernest Northfleet (A A–June 11.) 1800 w.

STEAM ENGINEERING.

3443. The Construction of Steam Boilers. Joseph Langdon (S E–April 16.) 2500 w.

3467. The Construction of Theoretical Indicator Diagrams for Compound Engines. Ill. W. C. Unwin (S V–April 15.) 750 w.

*3468. Steam Engine Work and Condensation. Ill. J. H. Slade (I L–April 8.) 1600 w.

†3540. Le Rôle de l'Eau dans les Cylindres à Vapeur. Ill. Lucien Auspach (R U M–Jan.) 24,000 w.

*3547. Note on the Practical Management of Locomotives. J. Esrey Johnson, Jr. (Cr–April.) 500 w.

*3553. Prévention de la Fumée dans les Tunnels. "El" (M I–April 12.) 1100 w.

3562. Centrifugal Force and the Fly-Wheel. Ill. W. H. Weightman (R G–April 22.) 1150 w.

*3590. Machines-Pilons Marines a Triple Expansion de la Société. J. Boulet et Cie. Ill. F. Desquiens (G C–April 9.) 1400 w.

*3630. Historical Analysis of Gears for Single Slide Valves. A. MacLay (I L–April 15.) 2300 w.

†3643. Emploi des Toles de Fer ou d'Acier dans les Chaudières des Locomotives. Historique de la Question. E. Belleroche (R U M–March.) 4400 w.

*3682. Boilers for High Pressure. Pulaski Leeds (I E–May.) 700 w.

3701. Working Sketches for a Pipe-Fitting Job. Ill. (Met W–April 30.) 250 w.

*3703. Coal Consumption of Locomotives. II. Geo. H. Baker (N C B–May.) 2800 w.

*3704. Who Should Feed a Boiler? Editorial (Ibid.) 750 w.

*3705. Testing Crank Pins and Firebox Sheets. (Ibid.) 800 w.

3808. The Amount of Air Required for Combustion. D. H. Welch (S E–April 30.) 950 w.

*3820. Locomotive Engine Boilers. Ill. H. R. Lehay (Eng L–April 22.) 1900 w.

3897. Engines of the Broadway Cable Road. Ill. (P S–May.) 1100 w.

3898. Reaction Strains upon Safety-Valves. Ill. R. C. Carpenter (Ibid.) 800 w.

3899. Boiler Room Practice. (Ibid.) 1200 w.

3900. The Steam Engine Indicator. The Expansion Line. Ill. (Ibid.) 1200 w.

3901. Clearance, Port Area, and Reheating. Louis I. Seymour (Ibid.) 1200 w.

3919. To Render the Use of Steam Safe. Editorial (Eng–April 30.) 1400 w.

3920. The Illusory Heat Unit. Editorial (Ibid.) 500 w.

3921. An Unconsidered Phase of Cylinder Condensation (Ibid.) 1400 w.

*3943. Air Pumps and Condensers for Steam Engines. Ill. Alfred Towler (Eng L–April 29.) 2900 w.

*3946. Slack Boilers. Editorial (Ibid.) 1500 w.

*4015. Proposed Steam Boiler Legislation. Editorial (I L–April 29.) 1200 w.

†4021. The Compound Locomotive of the Rhode Island Locomotive Works, Providence, R. I. Ill. (J F I–May.) 28,000 w.

4030. Waters Used in Locomotives. Wm. H. Edgar (S E–May 7.) 1800 w.

4048. Work and Power as Measured by the Steam Engine Indicator. I. Capt. Wright (C E N–May.) 3000 w.

4084. Correct Piping to Indicators. W. H. Odell (A M–May 12.) 600 w.

4085. Pitting in Boilers. T. T. Parker (Ibid.) 600 w.

4104. Points and Cautions in the Use of the Indicator (B J C–May 14.) 950 w.

4105. Waste of Coal. I. (Ibid.) 1600 w.

4165. Fuel Economy in Boiler Firing. Bertram Flint (M N–May 15.) 700 w.

4184. The Great Corliss Engine Break at Willimantic. Ill. (S V–May 15.) 1000 w.

4239. The Money Value of an Engineer (S E–May 14.) 1400 w.

4240. "Knocking" in Engines. Editorial (Ibid.) 800 w.

4363. The Principles and Practice of Smokeless Combustion. I. I. Bowe (S E–May 21.) 3800 w.

4365. The Size of Chimneys. Arthur Goodwin (Ibid.) 1350 w.

4445. Standard Locomotive Tests (R G–May 27.) 6000 w.

4446. The Steam Distribution in a Form of Single Acting Compound Engine. Ill. F. M. Rites (Ibid.) 3100 w.

4453. Steam Engineering of Electric Lighting Plants. Editorial (E M J–May 28.) 1300 w.

*4514. Vertical Boilers. Ill. Edward G. Hiller (Misc.) 1250 w.

*4525. Steam Engines. John Watts (C G–May 20.) 900 w.

4537. The Effects of Superheated Steam in Steam Engines. Frank J. Roth (S E–May 28.) 850 w.

4538. A Few of the Snags Struck by the Stationary Engineer. Ill. Sol. G. Pugh (Ibid.) 1150 w.

4539. The Principles and Practice of Smokeless Combustion. II. I. Bowe (Ibid.) 2300 w.

*4541. Coal Consumption of Locomotives. III. Geo. H. Baker (N C B–June.) 1300 w.

4564. The Utilization of Exhaust Steam for Heating by the Springfield, Ill., Electric Light and Power Company's Plant. Ill. W. Forman Collins (E E N Y–June 1.) 1200 w.

4565. The Economy of Condensing Engines Over-Rated. I. H. Babcock (Ibid.) 650 w.

*4605. Indicating the Engine on the Fastest Train in the World. Ill. Angus Sinclair (L E–June.) 2200 w.

*4606. Steel vs. Iron for Fireboxes. Editorial (Ibid.) 1200 w.

4626. Waste of Steam and Power (M N–June 1.) 1150 w.

4632. Steam Heating Below Atmospheric Pressure. Mr. Breckenridge (Met W–June 4.) 2100 w.

4644. Test of the Equator Steam Boiler. Ill. William J. Baldwin (A & B–June 4.) 1500 w.

4655. Work and Power as Measured by the Steam Engine Indicator. II. Ill. Capt. Wright (C E N–June.) 3700 w.

*4663. The Consumption of Smoke. William Metcalf (I S F–June.) 3000 w.

4664. New Developments in Steam Engineering. Ill. Geo. I. Rockwood (P S–June.) 2100 w.

4665. Arrangement of Boilers in Batteries. Peter H. Bullock (Ibid.) 1000 w.

*4718. Maximum Steam Jacket Efficiency. Editorial (I L–May 27.) 1400 w.

4726. Indicating Slide-Valve Engines. Ill. Chas. H. Garlick (S E–June 4.) 600 w.

4727. The Principles and Practice of Smokeless Combustion. III. I. Bowe (Ibid.) 2800 w.

4773. Vacuum Steam Heating. H. D. Crane (Met W–June 11.) 2600 w.

4801. Smoke vs. No Smoke. Editorial (Eng–June 11.) 1100 w.

*4812. Common Faults in Mill Engines. Ill. (P Eng–June 3.) 1400 w.

4820. Comparative Tests of Single Expansion and Compound Locomotives. Editorial (R R–June 11.) 2000 w.

4822. The Steam Distribution in a Form of Single-Acting Compound Engine. Ill. F. M. Rites (Ibid.) 3500 w.

MISCELLANEOUS.

*3368. New York's Commercial Blight. I. Ill. Wm. Nelson Black (E Mag–June.) 3000 w.

*3387. Artificial Rain. R. De C. Ward (G G M–April.) 1750 w.

*3388. Storms. Ill. Elias B. Dunn (Ibid.) 2700 w.

3402. Southern Iron in the North and West (M R–April 15.) 1500 w.

*3407. Sur les Notations Métriques et Autres. "El" (M I–April 5.) 1700 w.

*3426. The Manufacture and Industrial Value of Aluminium. Editorial (E R L–April 8.) 1500 w.

†3457. How Long Can the Earth Sustain Life? Robert S. Ball (F R–April.) 6500 w.

3460. An Aerial Problem. J. Eastus Price (M N–April 15.) 1000 w.

3461. The Recuperative Glass Tank. Ill. R. M. Atwater (A M & I W–April 15.) 5200 w.

*3463. Examination of the Standards of Measure and Weight Immured in the Houses of Parliament (Misc.) 1300 w.

*3464. Aberration Problems; a Discussion Concerning the Connection between Ether and Matter, and the Motion of the Ether near the Earth. Oliver Lodge (Misc.) 2000 w.

3505. The Engineering Schools of the United States. V. (E N–April 16.) 2900 w.

3508. Tests of Structural Wrought Iron and Steel. I. Alfred E. Hunt (Ibid.) 3300 w.

*3512. Paper-Making Processes and Machinery. I. James B. Bennett (M W–April 15.) 1900 w.

*3533. Shop Work Inspection. A. L. Johnson (J A E S–Feb.) 5000 w.

3537. The Manufacture of Steel Castings. J. A. Herrick (Misc.) 1250 w.

†3539. The United States Patent Office. I. Helen Frances Shedd (Ch–May.) 3500 w.

3558. The Engineering Schools of the United States. VI. (E N–April 21.) 6000 w.

3559. Tests of Structural Wrought Iron and Steel. II. Alfred E. Hunt (Ibid.) 3600 w.

*3561. Hydraulic Cements, Natural and Artificial. I. W. Cummings (Misc.) 2000 w.

3563. Specifications versus Brand. Opinions of Railroad Officials upon Methods of Purchasing (R G–April 22.) 1800 w.

3598. The New York Trade Schools. Richard T. Auchmuty (NAR–May.) 1500 w.

*3600. Sea and Land. III. N. S. Shaler (Misc.) 9300 w.

*3604. Working Economy. Walter J. May (I–April 15.) 2300 w.

†3612. Ten Years of the Standard Oil Trust. S. C. T. Dodd (F–May.) 4300 w.

†3613. Does the Factory Increase Immorality? Carroll D. Wright (Ibid.) 2000 w.

†3615. Ocean Traffic by the Erie Canal. Edward P. North (Ibid.) 2900 w.

*3623. On the Utilization of the Waste Forces of Nature. W. H. Preece (El–April 15.) 4500 w.

*3634. The Properties and Uses of Cast Steel Wire. M. L. Campredon (C G–April 14.) 1400 w.

†3641. Note sur le Retaillage des Limes et l'Emploi des Limes Démontables. Joseph Goffin (R U M–March.) 3400 w.

*3648. L'Utilisation des Forces Naturelles. Moulins à Vent. I. (Misc.) 2000 w.

3677. Wind Power Utilization. W. H. Booth (A M–April 28.) 600 w.

3688. Automatic Sprinklers (E N–April 28.) 1900 w.

3689. Standard Specifications and Tests. Editorial (Ibid.) 2300 w.

3690. The Engineering Schools of the United States. VII. (Ibid.) 2000 w.

3699. Pin-Holed Plates. Editorial (Met W–April 30.) 500 w.

3700. Pin-Holed Tin Plate. F. W. Moseley. (Ibid.) 900 w.

3721. Will the South Keep Pace with the North in Manufacturing? Edward A. Oldham (M R–April 29.) 1000 w.

3724. Coal Trade of Norfolk. A. Jeffers (Ibid.) 1000 w.

*3736. Municipal Engineering in St. Louis. Robert Moore (Misc.) 4400 w.

*3737. Government of Boston. William Jackson (Misc.) 2500 w.

*3738. Government of the City of New York. Francis M. Scott (Misc.) 2500 w.

*3739. Government of Providence, R. I. J. Herbert Shedd (Misc.) 800 w.

*3740. Government of Buffalo. E. B. Guthrie. (Misc.) 1500 w.

*3741. Government of Philadelphia. Dwight Porter (Misc.) 1000 w.

*3742. Government of Paris. Henry D. Woods (Misc.) 2800 w.

*3743. The Financial Status of the Engineer. Jos. Leon Gobeille (Misc.) 1750 w.

*3747. The Raisin Industry in California. Ill. Joseph T. Goodman (O M–May.) 8000 w.

*3748. California's Discovery of Gold in 1841. John Murray (Ibid.) 4000 w.

3768. Are Welsh Workmen Necessary to Establish Tin Plate Making in the United States? Editorial (A M & I W–April 29.) 600 w.

3780. Inventor and Capitalist. James Jay O'Connell (M N–May 1.) 1400 w.

*3798. Uniform Standard Time. (R A E J–May.) 900 w.

3807. Energy. III F. J. Roth (S E–April 30.) 2000 w.

*3826. A Giant Lighthouse Lens Quadrilateral Arrangement. J. R. Wigham (Eng L–April 22.) 2300 w.

†3831. Gas Wells Near Letts, Iowa. F. M. Witter (A G–May.) 1100 w.

3838. Internal Decay of Forest Trees. T. H. Hoskins (G & F–May 4.) 800 w.

3839. The Forests of California. William Alvord (Ibid.) 1600 w.

3840. German Forests as I Remember Them. Wilhelmine Seliger (Ibid.) 1000 w.

3864. The Manufacture of Gun Cotton (Misc.) 1000 w.

3865. The Proposed New Sheet Metal Gauge. Oberlin Smith (Misc.) 750 w.

3866. The Future of Southern Pig Iron. N. B. Johnson (Misc.) 700 w.

*3869. Steam Tree-Felling and Cross-Cutting Machinery. (E–April 22.) 1150 w.

3892. The South and the Beet-Sugar Industry. Edward A. Oldham (M R–May 6.) 2100 w.

3902. Effect of Temperature on the Tensile Strength and Ductility of Metals. I. H. Wade Hibbard (R G–May 6.) 3600 w.

*3922. Dust Counting on Ben Nevis. Angus Rankin (Misc.) 2700 w.

*3924. The General Circulation of the Atmosphere. J. M. Pernter (Misc.) 4400 w.

*3925. Cost of Production of Iron and Steel. Editorial (I–April 22.) 1700 w.

*3930. The Recovery of By-Products in Coke-Manufacture (Ibid.) 2000 w.

*3941. The Dangers of Petroleum Cargoes. J. H. Heck (C T J–April 30.) 1500 w.

†3966. The Place of Scientific and Technical Schools in American Education. Francis A. Walker (T Q–Dec.) 4500 w.

†3967. Some Considerations Regarding Helmholtz's Theory of Consonance. Charles R. Cross and Harry M. Goodwin (Ibid.) 4900 w.

†3970. An Apparatus for Determining the Liability of Oils to Spontaneous Combustion. Ill. Ellen H. Richards (Ibid.) 700 w.

*3973. Forestry in America. W. R. Fisher (Misc.) 1200 w.

*4013. Russian Industries (I L–April 29.) 1600 w.

†4019. A Practical Consideration of Compressed Air. Ill. Wm. L. Saunders (J F I–May.) 6400 w.

†4057. Geology of Perry Park. Ill. P. H. Van Diest (Misc.) 2900 w.

†4058. Municipal Engineering. Robert A. Wilson (Misc.) 1500 w.

†4063. Work with the Diamond Drill. Ill. R. D. Hobart (Misc.) 2200 w.

†4072. A Scheme for Technical Instruction. H. Llewellyn Smith (C R–May.) 5500 w.

4079. Bending Tests and Contraction of Area as Proofs of Quality. Ill. P. Kreuzpointner (E N–May 12.) 2000 w.

4089. The South and the World's Fair. Ill. (M R–May 13.) 28,000 w.

4116. The Cost of a Pound of Glass. R. M. Atwater (A M & I W–May 13.) 1700 w.

*4120. The Perfect Rubber Shoe. (I R W–May 15.) 1800 w.

4130. Domestic Light and Heat for Cities and Towns. I. William Waplington (P–May.) 1400 w.

*4135. Tinplate Making in America. Editorial (I–May 6.) 1400 w.

*4151. Some Remarks on Smoke and Fog Prevention. I. H. Coward (Inv–May 7.) 2300 w.

*4152. Dirigible Balloons. W. N. Hutchinson (Ibid.) 1800 w.

*4155. Another Use for Coke Bye-Products. Editorial (C E–May.) 1800 w.

†4157. Recent Science. Pierre Kropotkine (N C–May.) 10,000 w.

*4162. A Teaching University for London. Editorial (E–May 6.) 2100 w.

*4163. Royal Society Converzaione. Editorial (Ibid.) 2400 w.

*4175. Machinery for the Preparation of Tea. Editorial (Eng L May 6.) 1650 w.

*4186. The Aeroplane. Hiram S. Maxim (Cos-June.) 4800 w.

4191. Some Perpetual Motion Schemes. Editorial (A M-May 19) 900 w.

†4198. The United States Patent Office. II. Helen Frances Shedd (Ch-June.) 3300 w.

4211. Mensuration. B. F. Spalding (Misc.) 2300 w.

†4225. "The Great West" of Australia. Matthew Macfie (W R-May.) 8000 w.

4255. The Engineering Schools of the United States. IX. (E N-May 19.) 6000 w.

4259. The Engineering Schools of the United States. VIII. (E N-May 5.) 3900 w.

4273. Effect of Temperature on the Tensile Strength and Ductility of Metals. H. Wade Hibbard (R G-May 20) 2600 w.

*4286. Timber Tests for the United States Government. Ill. (I L-May 13.) 2100 w.

*4290. Some Remarks on Smoke and Fog Prevention. II. H. Coward (Inv-May 14.) 2300 w.

*4293. The Uses and Applications of Aluminium. G. L. Addenbrooke (Misc.) 6000 w.

4296. A Compressed Air Grain Elevator. Ill (R R-May 21.) 350 w.

*4309. Municipal Works in Nottingham. I. A. Brown (E-May 13.) 3000 w.

*4325. Report of the Royal Society's Committee on Color Vision (Misc.) 1750 w.

4362. The Profitableness of Forest-Culture. B. E Fernow (G & F-May 25.) 1400 w.

*4390. The Preservation of Our Forests. Thomas Magee (O M-June.) 2500 w.

4401. On the Elastic Curve and Treatment of Structural Steel. Gus Henning (E N-May 26.) 1600 w.

4409. The Engineering Schools of the United States. X. (Ibid.) 2400 w.

4413. Bye-Products in the Coking Process. I. (M R-May 27.) 1900 w.

4415. Dying Pine Forests. Editorial (Ibid.) 500 w.

†4433. Rates of Maximum Rainfall. Ill. Arthur N. Talbot (Misc.) 2800 w.

*4437. Windmills and Their Bearings Upon Electric Light, Water Supply, and Wholesome Bread. Ill. (S R-May 15.) 1200 w.

4447. Firebox Steel. P. Kreuzpointner (R G-May 27.) 2600 w.

4458. The Possibility of Extracting Precious Metals from Sea Water (E M J-May 28.) 400 w.

*4473. Modern Aerial Navigation. Editorial (E-May 20.) 1150 w.

*4475. Explosives Editorial (Ibid.) 750 w.

*4482. The Cultivation and Collection of Gutta-Percha. M. Sérullas (El-May 20.) 750 w.

*4489. Solidified Petroleum Blocks as Fuel (Inv-May 21.) 750 w.

*4492. The Protection of Metals from Corrosion (Eng L-May 20.) 900 w.

*4495. The Last Trial with Quartermain's Aerotransitor. Wm. Quartermain (Ibid.) 1350 w.

*4499. Vulcanization of Waterproof Fabrics (I L-May 20.) 1250 w.

†4501. Budapest. The Rise of a New Metropolis. Ill. Albert Shaw (C M-June.) 8800 w.

†4505. Mount Saint Elias Revisited. Ill. Israel C. Russel (Ibid.) 9800 w.

†4506. The Pressing Need of Forest Reservation in the Sierra. George G. Mackenzie (Ibid.) 1400 w.

*4507. Color Blindness. W. de W. Abney (Misc.) 6700 w.

*4508. Plate-Glass Manufacture in Germany (Misc.) 850 w.

4511. The Adoption of the Metric System. B. F. Spalding (Misc.) 2200 w.

†4535. On the Position of the Centre of All the Dry Land on the Surface of the Earth. John N. Stockwell (J A E S-April.) 6000 w.

4559. Forest Experiment Station at Santa Monica. Frank M. Gallaher (G & F-June 1.) 1900 w.

4586. How to Protect Inventions in Foreign Countries Without Effect upon the Term of United States Patent. Edward P. Thompson (Sc-May 27.) 900 w.

4587. The General Circulation of the Atmosphere. Ill. T. A. Bereman (Ibid.) 4200 w.

4588. Hot Water Heating and the Relation It Bears to the Plumbers' Trade. W. M. Mackay (D E-May 28.) 5900 w.

*4597. Conference de M. le Commandant Renard sur l'Aviation. L. Maurice (G C-May 21.) 2400 w.

4613. New Definitions of Stress and Strain. Editorial (E N-June 2.) 2400 w.

4615. The Utilization of the Power of Ocean Waves. Ill. (Ibid.) 5200 w.

*4654. Municipal Works in Nottingham. II. A. Brown (E-May 27.) 4200 w.

*4669. American Atlantic Liners. Editorial (Eng L-May 27.) 1500 w.

*4717. Russian Industries. Ill. (I L-May 27.) 2100 w.

*4730. Utilisation des Forces Naturelles. Les Moteurs Marins. I. Ill. (Misc.) 2500 w.

4738. Bye-Products in the Coking Process. II. (M R-June 3.) 1500 w.

4739. Conservatism in American Bleacheries. Herbert G. M'Kerrow (Ibid.) 2300 w.

4744. The Treatment of Steel. S. W. Goodyear (A M-June 9.) 1600 w.

4754. The Engineering Schools of the United States. XI. (E N-June 9.) 2500 w.

4755. The Anhydrous Ammonia Motor. John M. Batchelor (S R N-June 11.) 1300 w.

4765. Southern Timber Resources; the Supply of the Future. Ill. B. E. Fernow (M R-June 10.) 4600 w.

4767. Bye-Products in the Coking Process. III. (Ibid.) 1800 w.

*4804. Utilisation des Forces Naturelles. Les Moteurs Marins. II. Ill. (Misc.) 1350 w.

*4811. Steel vs. Wrought Iron. Editorial (P Eng-June 3.) 1500 w.

*4814. Indian Engineering Colleges (Eng L-June 3.) 1700 w.

*4831. The Duties of Resident Engineers. Editorial (E-June 3.) 3100 w.

*4836. Gondoriz on the United States Rubber Co. J. Orton Kerbey (I R W-June 15) 2700 w.

*4843. New York's Commercial Blight II. Ill. William Nelson Black (E Mag-July) 3000 w.

*4844. The Progress of Cremation. Ill. John Storer Cobb (Ibid) 3000 w.

*4845. The Facts About Rain-making. George E. Curtis (Ibid.) 3000.

NEW BOOKS OF THE MONTH.

[For the convenience of readers, any American books catalogued below will be supplied at publishers' prices by The Engineering Magazine Co. Foreign books, 25 per cent. extra.]

Adams, C. Kendall.=Christopher Columbus, his life and his work. New York: Dodd, Mead & Co. [12mo, cloth, 269 p., $1.]

Allegret, R.=Appareil Enregistreur des Flèches des Tabliers Metalliques, Système Parenthou. Paris: Hennuyer. [8vo, paper, 11 p.]

Allen, C. R.=Laboratory Exercises in Elementary Physics. New York: Holt. [12mo, cloth, 277 p., $1.15.]

Anney, J. P.=Manuel Pratique de la Lumière Electrique. Première partie. Installations privees. Paris: B. Tignol. [16mo, paper, 348 p., 5 *fr.*]

Barbet, E.=Les Appareils de Distillation et de Rectification. Etude comparative de leur consommation de vapeur et des resultats obtenus comme purification de l'alcool; theorie de la rectification; epuration des eaux-de-vie, taffias, genièvres, etc. Paris: G. Masson. [8vo, paper, 204 p., 5 *fr.*]

Beardmore, W. L.=The Drainage of Habitable Buildings. [12mo, cloth, 99 p. $1.50.]

Bending and Straightening Rolls. Hamilton, O.: Niles Tool Works. [4to, paper, free.]

Bethuys, G.=Les Aerostiers Militaires. Paris: Lecène, Oudin & Cie. [8vo, paper, 319 p.]

Bianconi, F.=Indicateur General de l'Industrie et du Commerce Francais pour l'Exportation et l'Importation. Paris: Chaix. [4to, 754 p., 5 *fr.*]

Boivin, J.=La Paix dans l'Usine par la Participation. Paris: Chaix. [8vo, paper, 40 p.]

Brongniart.=Etude des Effets du Tir Fusant et des Formations à Adopter sous le Feu de l'Artillerie. Paris: Berger-Levrault & Cie. [8vo, paper, 30 p., 1 *fr.*]

Buchetti, J.=Les Moteurs Hydrauliques Actuels. II. Construction. Paris: J. Buchetti, 92 Boulevard St. Germain. [4to, paper, 114 p.]

Campredon, L.=Les Moulages d'Acier: fabrication, composition, emplois. Paris: Rousset & Cie. [16mo, paper, 155 p., 3 *fr.*]

Carro, T.=La Vie à Bon Marche. Transports Economiques par la Navigation Fluviale. Etude nouvelle de barrage automobile. Paris: Michelet. [8vo, paper, 36 p.]

Catalogue of Presses, Drop Hammers, Shears, Dies and Special Machinery. A very full record of what has been accomplished in the construction of this class of goods. Brooklyn: E. W. Bliss Co., Ltd. [12mo, cloth, 389 p., free.]

Champion, L.=Monographie de la Compagnie des Trainways et Omnibus de Bordeaux. Historique de la dernière grève et epilogue. Bordeaux: Bellier & Cie. [8vo, paper, 94 p., 50 centimes.

Chapel, E.=Le Caoutchouc et la Gutta-Percha. With preface by P. Schützenberger. 245 illustrations. Paris: Marchal et Billard. [8vo, 615 p., 20 *fr.*]

Chaper, M.=Les Mines de Diamant de l'Afrique Australe. Paris: May & Motteroz. [8vo, paper, 24 p.]

Chapman, C. H.=An Elementary Course in Theory of Equations. New York: John Wiley & Sons. [12mo, cloth, 98 p., $1.50.]

Churchill, Randolph S.=Men, Mines and Animals in South Africa. New York: Appleton. [8vo, cloth, 352 p., $5.]

Clark, D. Kinnear.=The Steam Engine. New York: Blackie & Son. [8vo, paper, 12 parts, 1586 p., $1 each; cloth, 4 vols., $4 each.]

Clergerie and Calmel.=Etablissement Rapide d'un Pont Mobilisable en Acier sur le Var. Paris: Berger-Levrault & Cie. [8vo, paper, 48 p.]

Coumès=Apercus sur la Tactique de Demain, Mise en Rapport avec la Puissance du Nouvel Armement et l'Emploi de la Poudre sans Fumee. Paris: Baudoin. [8vo, paper, 714 p., 9 *fr.*]

Dallmeyer, J. H.=Du Choix et de l'Emploi des Objectifs Photographiques. Paris: M. Mayne. [8vo, paper, 42 p., 1 *fr.* 50.]

Deburaux, E.=Les Aerostats Militaires aux Grandes Manœuvres d'Armee de 1891. Paris: Berger-Levrault & Cie. [8vo, paper, 27 p.]

Delezinier, M.=Etudes d'Esotorisme Mathematique. I. Essai de Theorie simple de quelques phenomènes electriques comme base de mesure des effets de transformation de l'Od. Paris: Chamuel. [8vo, paper, 15 p.]

Delorat, A.=Navigation Aerienne. Aviation. Theorie et pratique. Paris: Wattier & Cie. [8vo, paper, 64 p., 10 *f c.*]

Demolins, E.=Le Socialisme devant la Science Sociale. Paris: Firmin-Didot & Cie. [18mo, paper, 77 p.]

Desroziers, E. and Bonneau, H.=Etude sur la Traction Electrique des Trains de Chemin de Fer. Lille: Lefebvre-Ducrocq. [8vo, paper, 19 p.]

Duquesnay.=Resistance des Materiaux. Paris: Gauthier-Villars et fils. [16mo, paper, 187 p., 2 *fr.* 50 *c.*]

Dwelshauvers-Dery, V.=Etude Experimentale Calorimetrique de la Machine à Vapeur. Paris: Gauthier-Villars et fils. [16mo, paper, 213 p., 2 *fr.*, 50 *c.*]

Eccles, R. G.=Study of Applied Sociology. New York: Appleton. [12mo, paper, 75 p., 10c.]

Estoc, M. d'=Le Genie da la Guerre, Le Developpement, les Erreurs, et la Logique de la Guerre. Paris: Dumont. [18mo, paper, 101 p.]

Etudes des Gites Mineraux de la France, publiees sous les auspices de M. le Ministre des travaux publics, par le service des topographies souterraines. Bassin houiller et permien de Brive. Fascicule 2: Flore fossile; par M. R Zeiller. Paris: Imprimerie Nationale. [4to, paper, 132 p.]

Fernand-Hue.=Aux Pays du Petrole. Histoire, Origine, Exploitation dans tous les pays du monde. Paris: Lecène, Oudin & Cie. [8vo, paper, 159 p.]

Fourtier, H.=Les Positifs sur Verre: Theorie et Pratique. Les Positifs pour Projections; Stereoscopes et Vitraux; Methodes Operatoires; Coloriage et Montage. Paris: Gauthier-Villars et fils. [8vo, paper, 215 p., 4 *fr.* 50 *c.*]

Garban, E.=L'Eau, Ses Proprietes, Ses Applications dans l'Industrie. Paris: Lecène, Oudin & Cie. [8vo, paper, 319 p.]

Gautier, E.=Les Etapes de la Science. Chroniques documentaires. Avec une preface de M. de Lanessan, gouverneur-general de l'Indo-Chine Francaise. Paris: Lecène, Oudin & Cie. [18mo, paper, 421 p.]

Genevrière, G.=Note sur la Comparaison des Prix de Revient de la Construction des Chemins Vicinaux par les Ingenieurs des Ponts et Chaussees et par les Agents Voyers. Paris: P. Dupont. [8vo, paper, 14 p.]

Gibon, A.=La Participation des Ouvriers aux Benefices et les Difficultes Presentes. Paris: Guillaumin & Cie. [8vo, paper, 135 p., 3 *fr.*]

Goulier, C. M.=Etudes Theoriques et Pratiques sur les Levers Topometriques et en Particulier sur la Tacheometrie. Paris: Gauthier-Villars et fils. [8vo, paper, 564 p., 8 *fr.*]

Greswell, W. Parr=Geography of Africa South of the Zambesi, with notes on the industries, wealth and social progress of the States and peoples. New York: Macmillan. [12mo, cloth, 412 p., $2.]

Grève Generale des Mineurs dans le Nord et le Pas-de-Calais. Paris. [8vo, paper, 31 p.]

Grey, Earl.=The Commercial Policy of the British Colonies and the McKinley Tariff. New York: Macmillan. [8vo, paper, 30c.]

Guttmann, O.=Blasting: a hand-book for the use of engineers and others engaged in mining, tunnelling, quarrying, etc. London; Griffin. [8vo, cloth, 190 p., 10s. 6d.]

Halphen, G.=La Pratique des Essais Commerciaux et Industriels. Matières Minerales. Paris: J. B. Baillière et fils. [18mo, 354 p.]

Hatch, F. H.=Mineralogy. London: Whittaker. [12mo, cloth. 132 p., $1.]

Houston, E. J.=A Dictionary of Electrical Words, Terms and Phrases. Second Edition. New York: Johnston. [4to, cloth, 568 p., $5.]

Hunt, E.=Color Vision: an essay discussing existing theories, explaining views hitherto incompletely published, and comprising illustrated descriptions of important new experiments. With three plates. Glasgow: Smith. [4to, paper, 124 p., 5s.]

Hurst, G. H.=Silk Dyeing, Printing and Finishing; with numerous colored patterns. New York: Macmillan. [12mo, cloth, 245 p., $2.]

Janes, L. G.=The Problem of City Government. New York: Appleton. [12mo, paper, 336p., 10c.]

Jannet, C.=Le Capital, la Speculation, et la Finance au Dix-Neuvième Siècle. Paris: Plon, Nourrit & Cie. [8vo, paper, 619 p., 8 *fr.*]

Lanquest, G.=Renseignements Divers Aux Amateurs Photographes. Conseils pratiques aux touristes et aux officiers en campagne. Paris: G. Lanquest, 1, Rue Gay-Lussac. [8vo, paper, 88 p., 2 *fr.*]

Laqueuille, H. B. de.=Petit Manuel d'Installation de la Lumière Electrique. L'Eclairage Electrique chez soi. Paris: J. Michelet. [18mo, paper, 79 p.]

Leaper, C. J.=The First Principles of Photography. An elementary treatise on the scientific principles upon which practical photography depends. London: Iliffe. [8vo, cloth, 266 p., 5s.]

Letourneau, C.=La Sociologie d'après l'Ethnographie. Paris: Reinwald & Cie. [16mo, paper, 624 p., 5 *fr.*]

Lock, C. G. Warnford.=Miners' Pocket-Book: a reference-book for miners, mine surveyors, geologists, mineralogists, millmen, assayers, and metal merchants all over the world. New York: Spon. [16mo, flex. leather, 472 p., $5.]

Magne, L.=Cours d'Histoire Generale de l'Architecture. Paris: Firmin-Didot & Cie. [8vo, paper, 66 p.]

Marshall, Alfred.=Elements of Economics of Industry. New York: Macmillan & Co. [12mo, cloth, 430 p., $1.]

Mason, Otis T.=The Land Problem. New York: Appleton. [12mo, paper, 254 p., 10c.]

McKinney, W. M.=American and English Railroad Cases. A collection of all the railroad cases in the courts of last resort in America and England. Northport, N. Y.: E. Thompson Co. [8vo, sheep, 756 p., $4.50.]

Mead, Edwin D.=Representative Government. New York: Appleton. [12mo, paper, 134 p., 10c.]

Merriman, Mansfield.=Text-book on Retaining Walls and Masonry Dams. New York: John Wiley & Sons. [8vo, cloth, 126 p., $2.]

Meyer, Lothar.=Outlines of Theoretical Chemistry. New York: Longmans, Green & Co. [8vo, cloth, 232 p., $2.50.]

Niewenglowski, G. H.=L'Objectif Photographique: Fabrication, Essai, Emploi. Paris: 4, Rue Antoine-Dubois. [Paper, 2 *fr.*]

Palaz, A.=Traite de Photometrie Industrielle Specialement Appliquee à l'Eclairage Electrique. Paris: G. Carre. [8vo, paper, 288 p.]

Palustre, L.=L'Architecture de la Renaissance. Paris: May & Motteroz. [8vo, paper, 352 p., 3 *fr.* 50.]

Patten, Simon N.=Theory of Dynamic Economics. Philadelphia: University of Pennsylvania. [8vo, paper, 158 p., $1.]

Peabody, Cecil H.=Valve Gears for Steamships. New York: Wiley. [8vo, cloth, 132 p., $2.50.]

Pensa, H.=De l'Intervention des Municipalites dans la Reglementation du Travail. Paris: Berger-Levrault & Cie. [8vo, paper. 55 p., 2 *fr.*]

Poirrier.=Discussion du Projet de Loi Portant Approbation d'Arrangements Signes entre Divers Etats de l'Union Internationale pour la Protection de la Propriete Industrielle. Paris. [8vo, paper, 29 p.]

Pollard, J. and Dudebout, A.=Architecture Navale. Theorie du Navire. Vol. 3. Dynamique du Navire. Mouvement de roulis sur houle, mouvement rectiligne horizontal direct (resistance des carènes.) Paris: Gauthier-Villars et fils. [8vo, 529 p., 15 *fr.*]

Poor, J. Alfred.=The First International Railway and the Colonization of New England; life and writings of J. Alfred Poor; edited by Laura Elizabeth Poor. New York: G. P. Putnam's Sons. [8vo, cloth. 404 p., $3.]

Rafter, Geo. W.=The Microscopical Examination of Potable Water. New York: Van Nostrand. [16mo, cloth, 160 p., 50c.]

Railway Officials' Directory. Chicago: Railway Age. [32mo., russia, 175 p.]

Reece, Benj.=Economies in Maintenance of Way. Second edition issued in response to large demand. Chicago: Q. and C. Co., 703-707 Phenix Building. [16mo, paper, 29 p.]

Report of the Rapid Transit Commission to the Massachusetts Legislature, with diagrams. [4to, paper, 296 p.]

Richon, G.=Constructions des Forts de la Meuse (Têtes de Pont de Liège et de Namur). Monographie des travaux executes par MM. Adrien Hallier, Letellier Frères, et Jules Baratoux. Paris: Baudry & Cie. [4to, paper, 73 p.]

Ringelmann.=De la Construction des Bâtiments Ruraux. I. Principes Generaux de la Construction. Paris: Hachette & Cie. [16mo, paper, 231 p., 1 *fr.* 25.]

Schloesing, H. and Degremont, B.=Moyen d'Arrêter Automatiquement un Train en Marche sur une Voie Encombree. Marseilles: Barlatier & Barthelet. [8vo, paper, 7 p.]

Schoeller, A.=Les Chemins de Fer et les Tramways: Construction, Exploitation, Traction. Paris: J. B. Baillière et fils. [18mo, paper, 362 p., 3 *fr.* 50c.]

Screws and Screw-Making, with a chapter on the milling machine. New York: James H. Wood. 10 E. 14th St. [8vo, cloth, 208 p., $1.25.]

Siacci, F.=Balistique Exterieure. Traduction annotee par P. Laurent, suivie d'une note sur les projectiles discoïdes par F. Chapel. Paris: Berger-Levrault & Cie. [8vo, 490 p., 12 *fr.*]

Spender, J. A.=The State and Pensions in Old Age. With introduction, by Arthur H. D. Acland, New York: Scribner. [12mo, cloth, $1.]

Taussig, F. W.=The Silver Situation in the United States. Baltimore: American Economic Association. [Paper, 120 p., 75c.]

Trutat, E.=Impressions Photographiques aux Encres Grasses. Traite pratique de photocollographie, à l'usage des amateurs. Paris: Gauthier-Villars et fils. [18mo, paper, 142 p., 2 *fr.* 75 c.]

COMMENT & CRITICISM.

The Mississippi Problem.

IT is a remarkable fact that in the discussions which have arisen in Congress upon the proper policy to be pursued with reference to the treatment of the Mississippi, the members who represent the districts adjacent to the stream are found to be warm advocates of levees, those more remote are less inclined to that method, while those members who are entirely removed from its influence are, in general, decidedly opposed to it.

The engineers employed on the river, who may at first be opposed to levees, learn in time to conform to the sentiment of the community, and it is therefore something of a surprise to find "A Southern Engineer" stating in THE ENGINEERING MAGAZINE that "Theoretically, and even without any reference to experience, it should be seen that building dikes along the shores of frequently swollen rivers must result in raising the bed over which the waters flow."

There are many engineers of note who maintain that by contracting and confining the raging stream between levees its velocity is increased and its *bed lowered*. The mistake made is in considering the effects in short reaches rather than taking the river as a whole. When it is remembered that it drains over 1,240,000 square miles, or about one-third of the entire United States, that its tributaries start at elevations reaching nearly a mile in altitude, that the disintegration from this extensive territory is finally deposited in the beds of the streams and rolled on towards the deepest thalweg whence it can only escape by being carried out through the mouths of the delta, some idea may be formed of the capacity of the dumping-ground required for the annual deposits of sediment. No one has ever attempted to show that the amount of sediment ejected from the river's mouths at all approximates that received from the tributaries or eroded from its banks and bed, yet it is a self-evident proposition that, unless these two quantities be equal, there must be an annual and permanent deposition in the bed of the stream causing that bed, taken *in toto*, *to rise*. This opinion has been bitterly denied, and it is even attempted to prove that the beds of the Po, Danube, Yellow, Ganges and other alluvial streams of lesser extent are not rising. In a state of nature the river has provided its own dump by overflowing the wide valley through which it flows, dropping its heaviest sediment near its edges and building up a traverse highest near the brink and sloping away from the borders to the lower swamps and bayous beyond. Thus the rich alluvial territory from Cairo to the Gulf has been constructed out of the terrain from the mountains and an ample dump has been furnished for the silt-bearing stream; but, if the river be leveled along its entire course and be compelled to bear its burden over these thousand miles, it will not be found able to cut deeper when surcharged with sediment, but it will drop its load in every available pool or bend at high water and assuredly and rapidly raise its bed.

The remedy suggested by our Southern author is to open up the lateral streams and divert some of the flood waters through more direct, shorter and steeper channels to the Gulf, the same as has been so frequently urged by Captain Cowden under the name of the "outlet" system and which has been so vigorously opposed by many engineers employed on the river because of the alleged formation of bars below the outlets. This feature, however, is even now being carefully studied by some members of the corps of engineers in charge of sections of the river, and the data thus far collected would seem to throw very grave doubts upon the supposed injury to the lower reaches from the outlets.

Following nature's method, however, and compromising with the land-owner, it would seem practicable to provide a suffi-

cient number of large lateral subsiding basins or lakes by enclosing extensive areas at intervals, where the topography admitted, of economical construction, into which the flood waters could escape and in which, the velocity being reduced, a large part of the silt would be precipitated, while, after the passage of the crest of the flood wave, the clearer water from those reservoirs would return to the river and become useful for navigation. In short, instead of serving the sole purpose of maintaining the water-supply for low stages, as do the reservoirs in the upper Mississippi, they could also reduce the rate of raising of the bed by providing lateral dumping grounds, outside of the bed of the stream, and would also reduce the flood plane and dangers from inundations. There are numerous places on the river where, by making return dikes extending back to the bluffs, many square miles of land now of little value might be utilized for such safety-valves for the river with substantial benefit and at a comparatively small cost. With reference to the probable effect of the lateral or outlet plan, while there is no grand precedent for it, there are many instances which would point strongly to its success, and one of the best which has fallen under my observation is to be found in the lowering of the flood plane of the Tyne in England due to the removal of bars and obstructions at its mouth and along its lower reaches as far as Newcastle.

Captain Cowden has reduced his outlet theory to the aphorism, "Make the outflow greater than the inflow, and there can be no overflow." In applying it he proposes to cut off a portion of the inflow by conducting it through lateral channels to the Gulf and thus preventing the tributary sediment from ever entering the main stream. This certainly is a desirable feature which appears to have been overlooked.

It certainly does not appear rational to expect any permanent improvement to a stream until the obstructions at its mouth and its surface slope in its lower reaches be increased, whether those obstructions be in the nature of deposits or mud or of water fed by tributary courses. The systematic improvements of the river must treat the problem as a whole and provide at high stages for the rapid emptying of its basin at the outlet, the retardation of its filling by its tributaries and provision for deposition of its load, and temporary escape of its excess of water along its course; while for the low-water stages for navigation, the stream must be canalized so far as practicable to retain a nearly uniform velocity. LEWIS M HAUPT.

Philadelphia, June 4, 1892.

"Sanitary Progress in New York."

IN justice to the departed an error in a contribution by Mr. C. F. Wingate, to your June number, needs correction. The Metropolitan Board of Health of 1866, was not organized with Dr. Elisha Harris Superintendent, but that office was filled by Dr. Edward B. Dalton; Dr. Harris was Corresponding Secretary. Dr. Harris was made Registrar of Vital Statistics the following year, and was the author of the excellent system—that has been, for the most part, followed ever since—which Mr. Wingate finds so hard to understand. Dr. Dalton resigned in January, 1869, and was succeeded by Dr. Harris, but on a reorganization of the Board the following year Dr. Harris was superseded by the appointment of Dr. Moreau Morris. In 1873, the Board was again reorganized by the appointment of Prof. C. F. Chandler, President, and the reappointment of Dr. Harris, Registrar of (Vital Statistics) Records, which office he filled for several years. It is no detraction from the high appreciation in which Dr. Harris is justly held as a practical sanitarian, that it was not his privilege to occupy the position attributed to him by Mr. Wingate in the City Board of Health, but the excellent service of Dr. Dalton as a skillful executive at the outset of the most effective health organization in the country should not be overlooked.

A. N. BELL.

Brooklyn, N. Y., June 3, 1892.